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GASOLENE ENGINES

THEIR OPERATION, USE AND CARE

A COMPREHENSIVE, SIMPLE AND PRACTICAL WORK

Treating of Gasolene Engines for Stationary, Marine or Vehicle Use. Their Construction, Design, Management, Care, Operation, Repair, Installation and Troubles.

Written especially for the Owner, Operator or Purchaser of Gasolene Motors who is unfamiliar with Technicalities and is not a mechanic or engineer. A book that is indispensable to the Amateur and of value to the Professional.

Containing also a complete table of Motor Troubles and Remedies and a full Glossary of Technical Terms used in Connection with Gasolene Engines.

By A. HYATT VERRILL

RANSPORTATI
UNIVERSITY

SECOND EDITION

Fully Illustrated with 152 Original Engravings

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PREFACE

In the preparation of this work the author has endeavored to produce a book which will serve as a practical guide and handbook to all those who at any time have occasion to use or operate gasolene engines. It is particularly intended for those with little or no knowledge of mechanics or engineering, and with this purpose in view technical terms and names have been practically eliminated from the text and descriptions, and explanations have been made as clear and plain as possible and as concise as a full explanation will admit. As technicalities cannot be entirely avoided in any work dealing with machinery, a full glossary of such terms, as applied to gasolene motors, has been added to the work, and the reader who is without any knowledge whatever of machinists' and engineers' terms will find in this feature a ready reference and explanation.

Appreciating the value of illustrations as an aid to text description, the author has endeavored to figure each and every part and feature treated in the work; and in order to make the illustrations more plain and understandable every part or portion not directly related to the point under discussion has been eliminated in the figures.

The illustrations are in no sense working drawings, but are mainly diagrammatic, and no attempt has been made to draw them to accurate scale, while in order to bring out certain features of construction or operation such features have been purposely exaggerated. This is the case with the tapered shafts on page 96, as well as with the pitch of various screw threads and gear teeth. This may be wrong theoretically, but in serving its purpose it is good practically, which is exactly the reverse of many theories in mechanics and engineering.

While volumes might be devoted to enumerating and describing *all* the troubles which *might* occur in gasolene-engine operation, yet the number that are likely to be met are comparatively few and are fully covered in the alphabetically arranged table of troubles in the work.

The plain and simple tables of screw threads, pipe sizes, etc., will, it is hoped, prove of value, especially to those having occasion to replace or order fittings or screws.

The chapter on useful hints and makeshift repairs has been compiled from actual experience and each has been tried and tested many times in real practice.

The author sincerely hopes that the work will prove as useful and valuable to all his readers as a similar work would have been to him in the early years of his gasolene-motor experiences.

MAY, 1918.

INTRODUCTION

The discovery of the Gas Engine marked a new era in mechanical progress and its perfection has led to some of the most marvellous and important of modern inventions and achievements.

Through its use aëroplanes and submarines have become possible, and motor vehicles of all kinds depend largely upon the gasolene engine for power; while motor boats, launches, and power cruisers have placed yachting within reach of the man of moderate means, whereas a few years ago the use of steam confined this pleasure to the wealthy few.

Useful and important as the gas motor has proved for vehicle and marine use, even more valuable are its services in stationary form. In factory, home, and farm the stationary gasolene engine is in daily use, performing steadily and easily the work of many hands at a fraction of the cost of the old steam engine. On the farm especially has the explosive motor proven its worth, and this light, simple, portable power-plant has revolutionized farm work in many sections. Labor that was formerly slow and irksome is now performed easily, quickly, and pleasurably and the ingenious farmer finds a thousand and one uses for his motor. It will separate his cream, turn his grindstone, do the wife's washing, and light the home with electricity; and if mounted on a "tractor" it will plough and harrow the fields, plant and cultiv the crops, and will mow, thresh, and grind the grain.

When we consider the manifold uses of the gas eng and the number in daily use it seems surprising that few owners, operators, or users thoroughly understa their engines or their construction, operation, or ca Many a man who would feel incompetent to operat steam engine will undertake to handle a large or co plicated gas engine; and yet, as a matter of fact, latter is by far the more delicate piece of mechanis It certainly speaks well for the modern gas motor th under the ordinary conditions and in the hands of many people absolutely ignorant of the first princip of engineering or mechanics, there is so little trou It is no uncommon thing to hear the owner of a gasol engine boast that his motor has run so many miles or many hours without missing an explosion. Did ever hear a steam-engineer boast that *his* engine had a few hours or a few days without blowing up the boi or bursting a cylinder?—and yet there is as much rea for one as for the other. If a gas motor is prope adjusted and runs smoothly for an hour there is earthly reason why it should not continue to run days, months, or years, as long as it is fed fuel, lu cating oil, and electric current, and ordinary wear tear are attended to, as in any other piece of machine

The idea that a gas engine must give trouble, that i an obstinate and balky thing, and that it will fail at most critical time without cause is pure nonsense. gas engine fails to operate there is some good and s cient reason; for the modern gas engine is no lon an experiment, made by guess and by hand, but is a thoroughly well made, carefully designed, and well tested mechanical device; but like any other machine, to operate successfully, it *must* be given certain conditions. Nine times out of ten the "balkiness and obstinacy" are in the operator and not in the motor, and a little common sense and judgment will do far more than a lot of swearing, cranking, and hit-or-miss adjusting.

One often sees a man operating a motor, which is running smoothly and well, continually loosening a nut or screw here and tightening there, or fooling with some part or another of his engine. This practice is sure to cause trouble and sooner or later the motor skips and stops. Being perfectly ignorant of the cause, or of the former adjustment of the parts, the operator tries one thing after another and eventually either gives up in despair or by pure luck gets the motor running. In the former case a repairman's bill results in blaming the motor and gas engines in general, while in the latter case our friend flatters himself that he knows all about gas engines and thereafter poses as an expert with a fund of ready advice to every other user of a motor; and yet, should the same trouble arise again, he would be as much at a loss as before. This sort of trouble is far commoner with marine motors than with those in motor vehicles, for in a boat the engine is exposed and within easy reach, whereas in the vehicle it cannot be touched or meddled with while operating. It is mainly for this reason that vehicle motors appear to run more regularly and reliably than marine motors. Of course one now and then runs across an old, poorly designed, or worn-out engine that will run badly and cannot be depended upon, but in most cases a little adjustment here and there, a little lubrication, or some other small matter is all that is required. During a number of years' experience in handling and repairing gasolene engines, the author has yet to find a motor which could not be made to run—save in one or two cases where the engine was completely worn out and fit only for the junk heap.

Many books have been written on gas engines and their care and operation, but in the majority of cases these works are either too technical or are confined to one particular class of engines. Others describe and discuss oil, kerosene, and producer-gas engines, as well as those designed to operate on gasolene, and this is apt to be very confusing to the inexperienced, for while, strictly speaking, all these *are* gas engines, yet the individual peculiarities of different fuels require certain variations in design and operation in the motors and each should be made a separate study in itself. The purpose of the present work is to furnish all the necessary information regarding gasolene engines in simple language free from technical terms and as far as possible cover all variations, types, and classes of these motors and their various parts, accessories, and appliances. In order to illustrate the various types of engines and devices certain makes with distinctive characters have been used as examples, but the author wishes it clearly understood that such mention of a certain make of engine or accessory does not imply that it is the best or that it is recommended or endorsed by this work. Such mention merely indicates that the motor or appliance is typical of its class and is a well known and standard make.

As the number of gasolene motors on the market is steadily increasing and there are over ten thousand manufacturers of explosive engines in the United States to-day, it is practically impossible to mention more than a very limited portion of the various designs, innovations and improvements constantly being made in this industry. In all gasolene engines the principle is the same, and the care and operation identical, and the man who becomes thoroughly familiar with one engine will have no trouble in mastering any other.

As technical terms cannot be avoided under certain conditions, such as ordering new parts, making repairs, machine-shop work, etc., a glossary of such terms with an explanation of the meaning of each has been added to the work as well as an alphabetically arranged table of common troubles and their symptoms and remedies, features which the author believes will prove of great value to all owners, users, or operators of gasolene motors.

GASOLENE ENGINES

CHAPTER I

TYPES OF MOTORS. OPERATION AND EXPLANATION OF TWO-CYCLE AND FOUR-CYCLE MOTORS

ALL gas, gasolene, or oil motors, known collectively as Explosive Engines, may be roughly divided into two classes or types: the Two-cycle or Two-stroke engines and the Four-cycle or Four-stroke engines.*

While these two types are quite distinct in their construction and operation, yet the principle in each is the same. A charge of gas, gasolene, or oil vapor is drawn into the cylinder, is compressed therein by a piston, and while under compression is ignited by an electric spark or similar device. The force of the exploding gas drives down the piston which, acting upon a crank, transmits the power of the explosion to a revolving shaft and thence to the boat, vehicle, or machine requiring the power.

It will thus be seen that a gas of the highest explosive power, an ignition device that can be depended upon, and a cylinder that will not leak and lose compression are the most necessary essentials for the proper operation of a gas motor.

---

* The author is well aware that certain six-cycle motors have been built and used to some extent. In these engines the additional idle stroke is utilized to draw a charge of clean air into the cylinder in order to more perfectly scavenge the burnt gases. Such motors have not come into general use, however, and the ordinary operator is not likely to encounter an engine of this type. They are not considered of sufficient importance to be worthy of consideration in the present work.

The simplest form of gasolene engine is the Two-cycle in which the parts may be reduced to a minimum, only three moving parts being absolutely essential (Fig. 1).

In this figure the piston *A* is represented as being at the upward limit of its stroke with the space between the top of piston and top of cylinder *B* filled with a charge of compressed gas. At this position, or "Firing Stroke," an electric spark takes place at *C* and ignites the gas which, exploding, drives the piston *A* downward. At the point illustrated in Fig. 2 the opening *D* in the cylinder wall is uncovered by the piston, and the burning and practically exhausted gas rushes out through this opening and escapes. Almost at the same instant the opening *E* is uncovered and a fresh charge of gas—which has been contained in the base *F*—is forced up through the opening *G* to take the place of the exhausted charge (Fig. 3). The momentum of the moving fly-wheel and shaft now carries the piston on its upward course, closing the openings or "ports" *D* and *E* and at the same time drawing by suction a fresh charge of gas or gasolene vapor into the base through the opening *H* (Fig. 4). As the piston reaches the top of its stroke a spark again ignites the compressed charge, the piston is again forced down, and the operation repeated over and over again. In this motor it will readily be seen that an explosion or impulse takes place at every complete revolution of the shaft or, in other words, at every *two strokes* of the

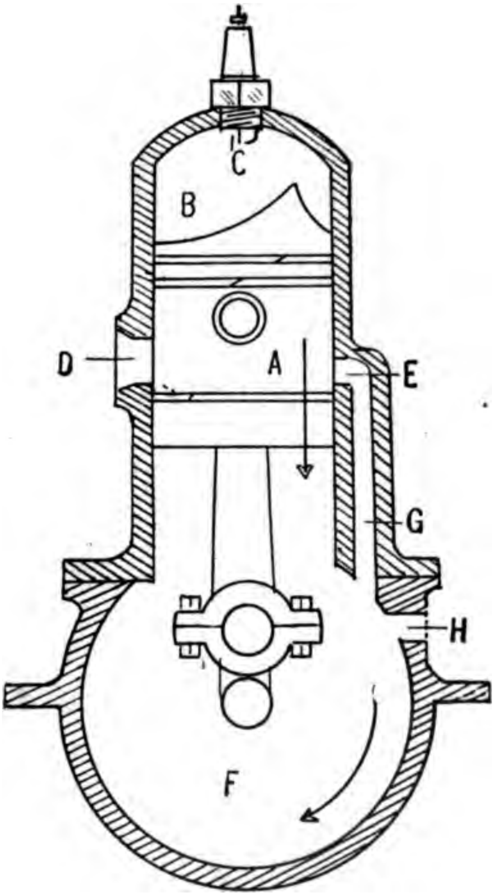


Fig. 1.—Operation of Two-cycle Engine

(See page 16)

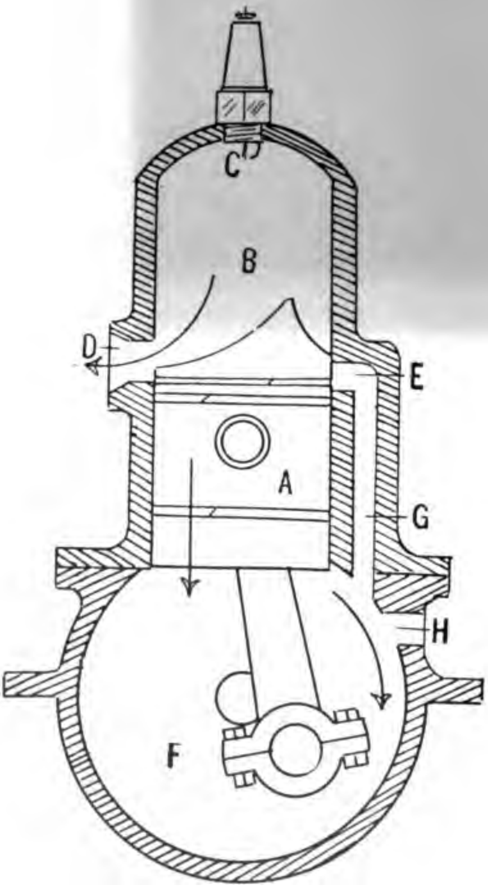


Fig. 2.—Operation of Two-cycle Engine

(See page 16)

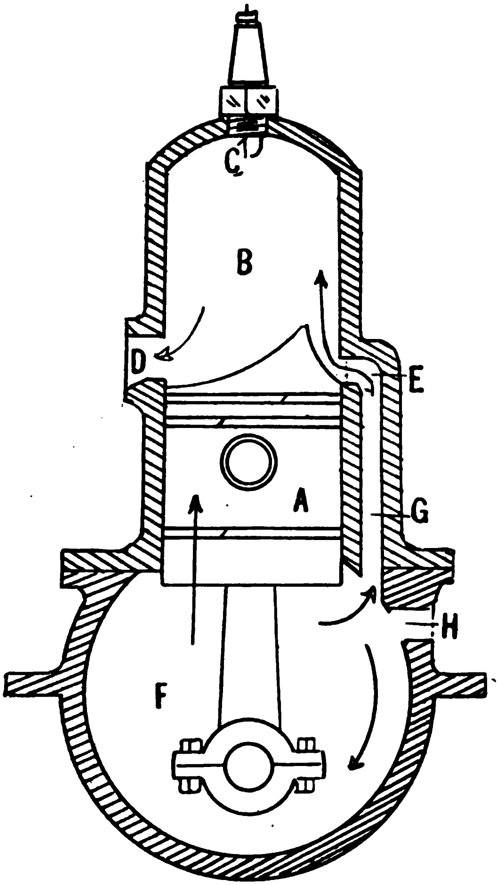


Fig. 3.—Operation of Two-cycle Engine

(See page 16)

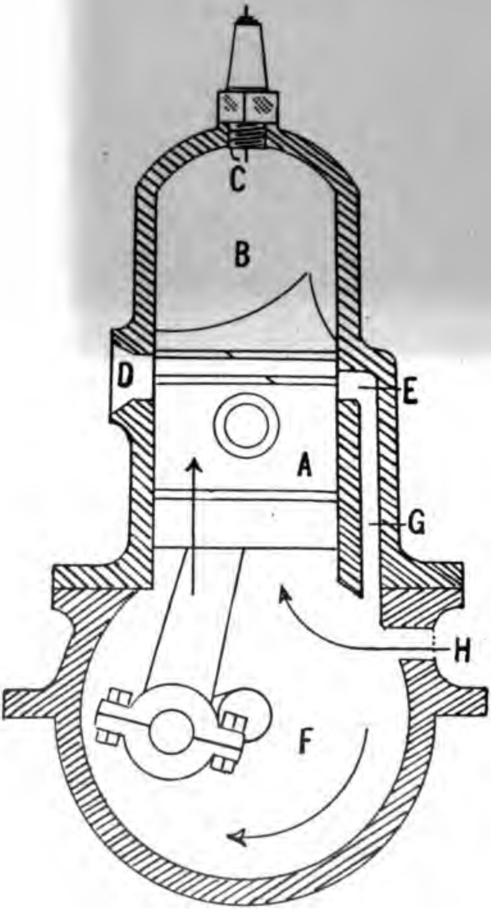
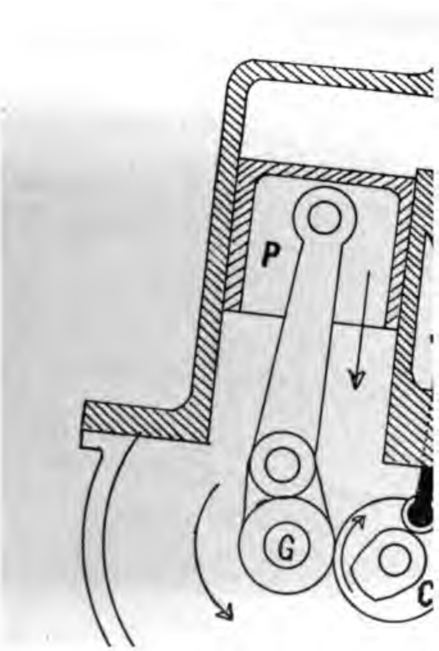


Fig. 4.—Operation of Two-cycle Engine

(See page 16)

piston. In order to first start a two-cycle motor in its operation a charge of gas or vapor must be drawn into the base and forced up to the top of the cylinder and compressed there. One complete revolution of the shaft is necessary to accomplish this, and this revolving a shaft by hand is commonly known as "cranking." Unless a motor is out of order or some adjustment is wrong one revolution only should suffice to start the engine, and if it fails to start then further cranking is merely a waste of time and strength until the fault is corrected. Indeed most motors when properly adjusted will start by merely rocking the fly-wheel back and forth and "throwing it up" against compression. In cold weather, however, motors will often start very hard and at such times "priming" should be resorted to. This matter will, however, be fully dealt with in the succeeding chapters.

In Figs. 5 to 8 a section of a four-cycle engine is illustrated. In this type of motor the parts are far more numerous and the operation more complicated. The motor is shown in Fig. 5 with the piston *P* at the top of stroke or "firing stroke," with a compressed charge ready to explode, and with both the valves *VI*, *VE* closed. The explosion taking place the piston is forced down as in the two-cycle motor already described, and the shaft is turned half a revolution. In its downward passage the exhaust valve *VE* is opened through the action of a cam *C* and gear *G* connected to the main shaft, and the motor then appears as illustrated in Fig. 6. The piston now commences its upward stroke, thus forcing the burnt gas out through the exhaust valve


P
G
C

eached. The intake valve *VI* now closes, and as the xhaust valve *VE* still remains closed the upward stroke the piston compresses the gas until again ignited by

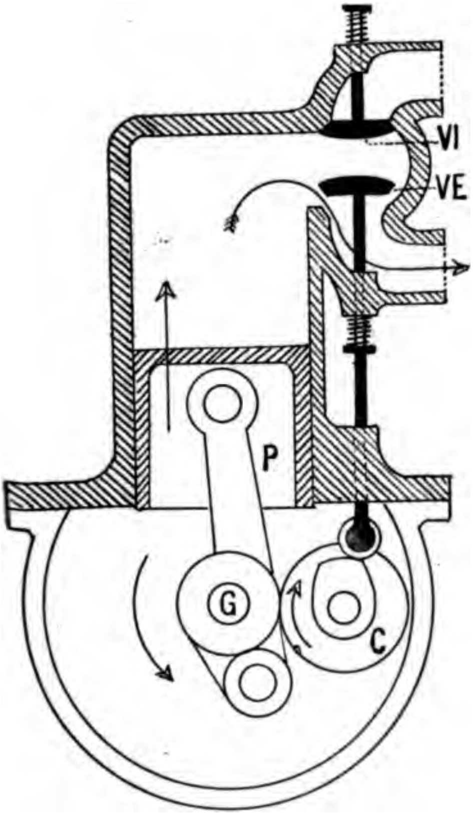


Fig. 6.—Operation of Four-cycle Engine

the spark (Fig. 8). The operation is then repeated over and over. By reference to the figures and the explanation it will be seen that in this form of motor an explosion takes place at every *two revolutions* of the shaft every *four strokes of the piston.*

To the uninitiated it would appear that an

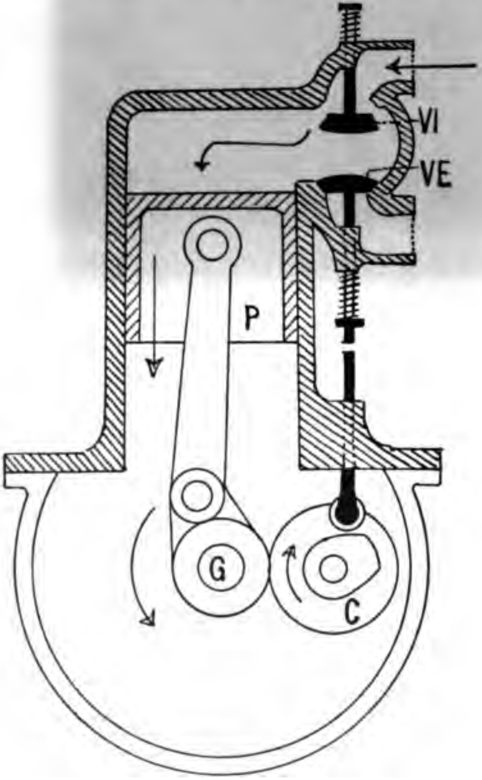


Fig. 7.—Operation of Four-cycle Engine

receiving an explosive impulse on every two s would naturally be more powerful and would run steadily and with less vibration than a motor rec impulse only on every fourth stroke. In reality re is but little difference in the power delivered by a o-cycle or a four-cycle engine; while as a rule steadi-

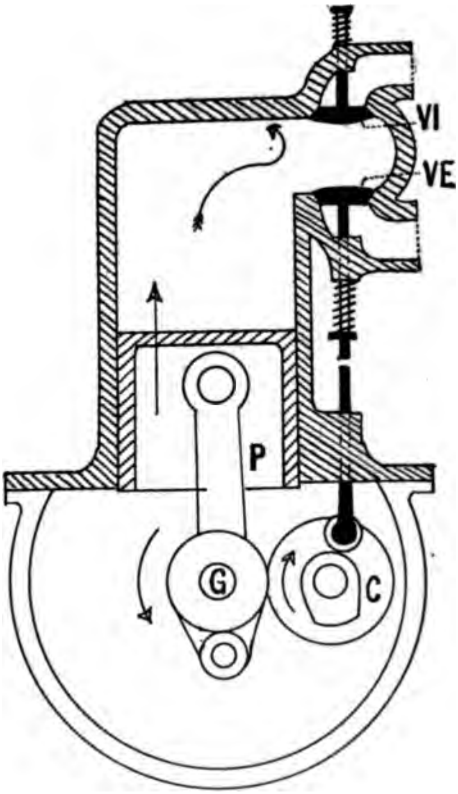


Fig. 8.—Operation of Four-cycle Engine

s and reliability are in favor of the four-cycle motor. bably the four-cycle motor uses less fuel for the same wer than a two-cycle, but even this may be doubted in the case of many of the better classes of two-cycle engines. In the four-cycle type the burnt gases have a longer opportunity to escape, besides being mechanically forced out by the piston itself, and as a result the fresh charge of gas is purer and possesses better explosive properties and more power. Moreover, the idle stroke allows the cylinder more time to cool off while the valve action regulates the amount of charge taken into the cylinder more accurately than in the fixed opening, or port, of the two-cycle type. Each type of motor has its devotees who claim all the advantages for their own particular type, but it is doubtful if there is any great difference as far as actual utility is concerned. Both the two- and four-cycle types are used extensively in stationary work, but for light marine work the two-cycle type is the most used. For larger boats and where great power is desired the four-cycle engines predominate, while in automobiles and other motor vehicles four-cycle engines are almost universally used. This seems to be due to the greater perfection of the four-cycle engines rather than to their actual performance as compared with the two-cycle, for in a few makes of cars the latter are employed with very marked success. Although the two-cycle is so much simpler in construction and operation yet it is harder to design and build a really good two-cycle motor than a four-cycle, and usually it requires more care and more knowledge to regulate and adjust one correctly. This seeming paradox is explained by the fact that in a four-cycle motor the timing and regulating of the valves may be made to overcome many faults in the design or construction of the motor or its parts, whereas in the two-cycle motor every measurement must be within very exact limits in order for the motor to work at all. In adjusting motors the valves again cause the four-cycle to be the simpler, for a considerable difference in the amount of air or fuel, or even in more important matters, makes but slight difference in the apparent working of the motor, whereas in the two-cycle type a very slight difference in the proportions of the fuel causes a marked difference in the results obtained.

It has been claimed by many that the four-cycle is more flexible, or, in other words, can be varied in speed and power to a greater extent than the two-cycle motor, but I am inclined to doubt this. A properly designed and constructed two-cycle motor may be run satisfactorily at from one hundred to several thousand revolutions per minute without trouble, and many of the best four-cycle engines fail to run at all regularly when the speed is varied suddenly to any extent.

A very important point that is all too frequently overlooked by the owner or user of gasolene motors is the "human element." One man will get splendid results from a certain type or make of engine while another person will have continual trouble with it and condemn it outright. This peculiar adaptability, or "knack" as it may be called, of some operators with certain engines seems remarkable at first sight, but if carefully studied will usually prove to be due to the fact that the operator has thoroughly *learned* his engine. No two gasolene motors are exactly alike, and no two engines will run equally well with exactly the same treatment. This is more often due to surrounding conditions than to the motor itself, but nevertheless I have yet to see the engine that does not require some "humoring" and for this reason I strongly advise every purchaser or user of a gasolene motor to be sure that he has thoroughly mastered *his* motor and learned its ways before deciding that there is really anything wrong with the mechanism itself.

Before deciding on the type or make of motor suited to your particular requirements, study the matter carefully and study the advantages and disadvantages of each until thoroughly satisfied that you have selected the best motor for your purpose. There are many hundreds of motors made, and while practically every well-known and reliable firm turns out a good motor nowadays, yet some are better than others and each make and type possesses certain advantages that fit it for particular purposes or conditions.

Do not expect to get a first-class motor at an absurdly low price. It costs money to design and build a good engine, and while the large manufacturer, with special tools and machinery and every facility for turning out motors in large numbers, can make a much lower price than the man who makes each motor by hand and builds only a few at a time, yet if a motor is advertised at a *very* low figure, steer clear of it. As a rule the motors made by large firms at a reasonable price are far better than those made in small numbers at a high price, for in the former case the parts are interchangeable and new pieces may be purchased at a low figure and *will always fit,* whereas the small manufacturer seldom turns out parts that do not require considerable hand work before they can be made to fit an old motor. Many manufacturers depend on overrating their motors to increase sales. They will advertise a motor at almost double its actual power and sell it at the price others charge for the actual power advertised and thus appear to sell a motor at a very low price. Usually such motors are extremely high-speed, short-lived engines, or else the maker is deliberately trying to defraud you. There is no excuse for being swindled, however, for it is a simple matter to determine the horse-power of any motor. Bore and stroke and speed give the power, and while various motors may give more or less power according to design and workmanship, yet within certain limits the power may be readily determined.

The amount that the explosive gas is compressed before ignition also affects the power of the motor, as well as the proper adjustment of fuel, proper lubrication, and correct ignition. The power computed from these established factors is known as the *Indicated Horse-power*, but the whole of this power is never available. A large part is consumed in overcoming the friction in the motor itself, and the power remaining after this is overcome is called the *Delivered Horse-power*. The proportion of the Delivered Power to the Indicated Power is known as the *Mechanical Efficiency*, and is usually expressed in per cent. Thus if the Indicated Horse-power of an engine is 10 H.P. and the Delivered Power is 8 H.P., the Mechanical Efficiency will be 8/10 or 80 per cent, and the friction load (overcome in operating) will equal 10−8 or 2 H.P. While the pressure of the gas under compression varies considerably, according to the fuel used and design of engine, yet the pressures are so well known and the proper pressure so well established that an average of about 70 pounds per square inch may be counted on. With these factors known the following formulas may be depended upon to ascertain with reasonable accuracy the Delivered Horse-power of any gasolene motor.

For four-cycle motors: D.H.P. = Diam. of cylinder multiplied by itself, times the length of stroke, times the number of revolutions per minute, divided by 18,000. For example, the D.H.P. of a motor with a 3-in. bore, 3-in. stroke, running 1,000 revolutions per minute = 3×3×3×1,000 = 27,000, divided by 18,000 = 1½ D.H.P.

For the D.H.P. of a two-cycle motor proceed in the same manner, but divide by 13,500. Thus, a two-cycle motor with 3-in. bore, 3-in. stroke, and operating at 1,000 revolutions, would show 3×3×3×1,000 = 27,000, divided by 13,500, or 2 D.H.P.

Usually motors are tested by some form of pressure brake and the D.H.P. thus obtained is called *Brake Horse-power*. Such tests are reliable and accurate, but it must be borne in mind that the motors while undergoing these factory tests are operated under the most favorable conditions and by skilled engineers and mechanics; and the same motor that delivers 10 H.P. under a factory brake-test may not deliver over 6 H.P. when installed and operated by yourself.

It is far better to have too much power than too little, and a few horse-power more or less makes little difference in price. All other things considered you should choose the motor having the longest stroke and largest diameter and operating at a medium speed. High speed means short life, and large bore and short stroke mean high speed. Extreme long stroke and small bore, however, mean slow speed and additional weight, and an excess of either is undesirable.

With these remarks on the operation and principle of gasolene engines in general, we will now take up the matter of the various motors and their parts and accessories in detail.

CHAPTER II

TWO-CYCLE OR TWO-STROKE MOTORS

THE two-cycle motor already described and figured in the preceding chapter is known as the Two-port motor from the fact that there are but two openings, or ports, from the cylinder. Another form of two-cycle motor in common use is known as the Three-port motor (Fig. 9). The operation of this motor is essentially the same as the two-port type, but in addition to the two ports this motor has a third port or opening, *A*, which is closed by the piston acting as a sliding valve. On the downward stroke of this motor the third port is closed as shown in the figure, while the gas in the base is forced up to the top of the cylinder through the by-pass *B*. On the upward stroke the gas is sucked into the cylinder through the port *A*, as in the two-port type. The only advantage of this type of motor over the two-port is that no check valve is required in the inlet for fuel at *A*. It is usually a high-speed engine, and as a partial vacuum is created in the base on the upward or suction stroke and a considerable pressure must be maintained on the downward stroke, tight bearings and joints are essential and these, especially in a marine engine, are hard to retain for any length of time. Many of the more recent types of two-cycle engines are constructed so that either a two- or three-port system may be used as desired. A very successful motor of this design is the Gray Model "T,"

rated in Fig. 10. Almost any good three-port
r may, however, be transformed to a two-port

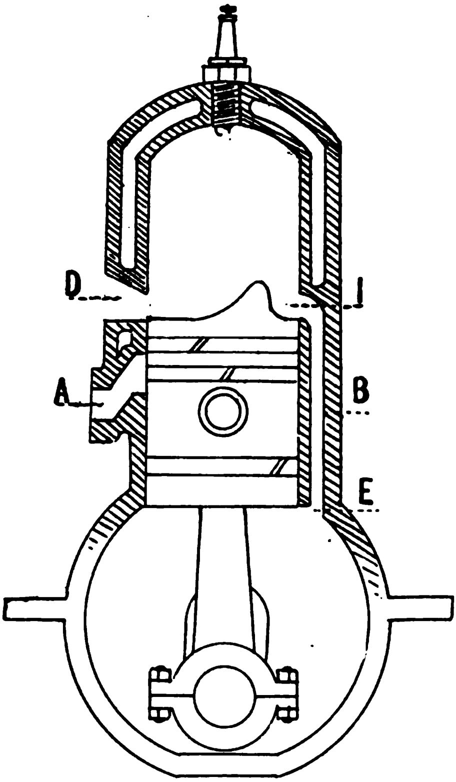


Fig. 9.—Three-port Motor

e even after its efficiency as a three-port has
ed.

ny of the best so-called two-port motors are in
y a sort of combination of the two- and three-port

types. Such a motor is illustrated in Fig. 11. In this motor the inlet, or fuel, port, instead of being in the base as illustrated in Chapter I, is situated in the by-pass *B* midway between the base and the inlet to cylinder *C*.

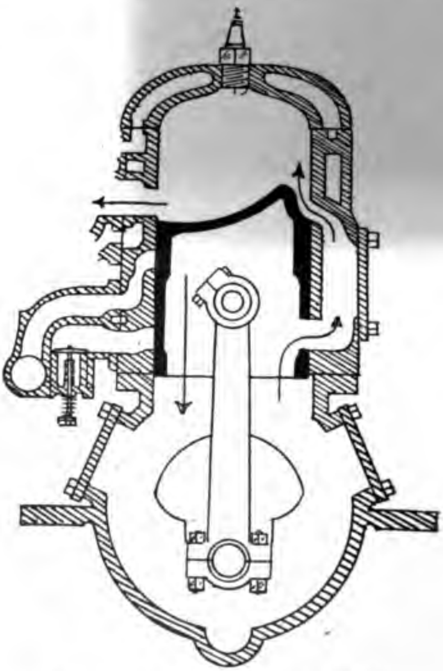


Fig. 10.—Gray Model "T" Motor

The operation of this type of motor is precisely the same as in the straight two-port, but it possesses many advantages over either the two- or three-port type. The suction created by the piston is greater than in either of the other types, while no great pressure is required in the base

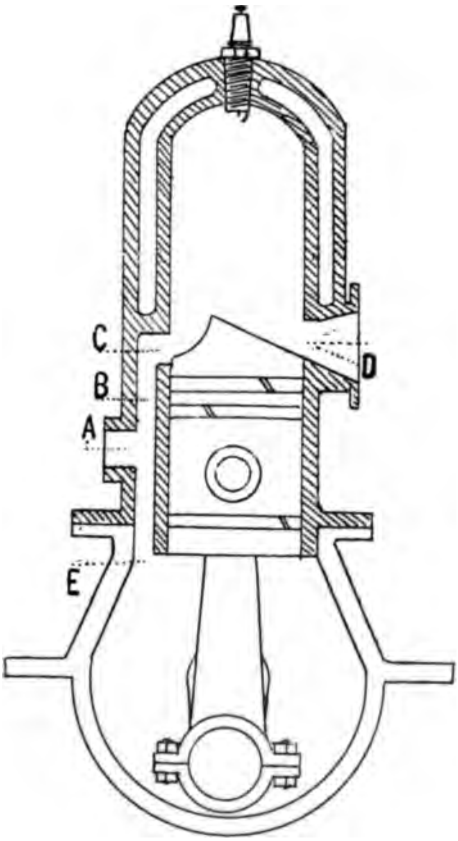


Fig. 11. Two-three-port Motor

as in the three-port. The fuel-mixing device is elevat more than in the two-port, which is a distinct advanta in a boat, and the gas or vapor striking on the walls the by-pass, instead of on the base of the engine, resu in far better vaporization and consequently bett combustion. The walls of the base are usually cold nearly so and the mixture of gasolene and air ten to cool them off even more; whereas in the motor unc consideration the walls of the by-pass are always wa while the motor is in operation and the mixture of ga lene and air striking this warm metal is immediat thoroughly vaporized. Many of the motors of this ty have an opening in the base into which the fuel inta may be screwed. In such cases the operator may his motor as a regular two-port or as a combination desired. In many motors of this class very super results are obtained by attaching an auxiliary air in in the base. This is closed when starting or runni slowly, but when running at high speed is gradua opened until the best possible results are obtain Such an auxiliary inlet is shown in Fig. 12 (*A*), and known as an "Accelerator."

Two-cycle motors are also made which possess so of the best features of both the two- and three-p types. An example of this style of engine is the Gras motor illustrated in Fig. 13. This motor has a vapori *A*, as well as an automatic air valve *B*, a third port and a transfer port *D*, which acts as the second port o two-port motor. In operation the piston on its upwa stroke draws a charge through the vaporizer *A* into t crank case *E*, until it reaches a point where the thi

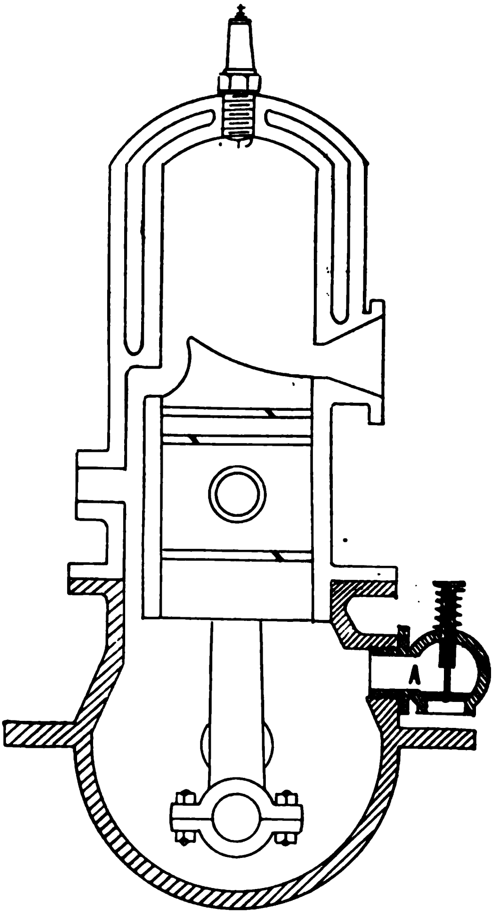
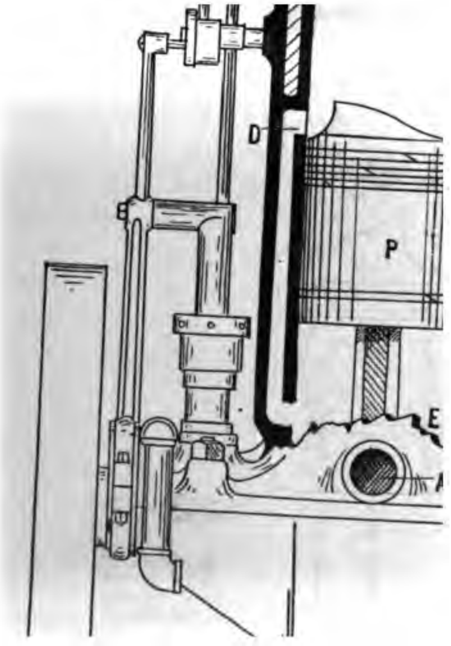


Fig. 12.—Two-three-port Motor with Accelerator


D
P
E
A

port *C* is uncovered. This permits the vacuum remaining to be displaced by air through the air valve *B*. As soon as the piston starts on its downward stroke the valve in *A* closes and the charge in the base is forced up through the transfer port *D* into the cylinder. This arrangement permits of a large, full charge of gas with consequently higher compression, more power, and freedom from crank-case explosions. In this motor the ports are placed in the forward and rear sides of the cylinders: by this method the piston and cylinders wear longer than if the ports were cut in the sides of the cylinder walls as the main thrust of a piston is sideways.

Still another type of two-cycle engine is so constructed as to admit the charge from the base through a port in the piston walls and hence through a by-pass and valve in the top of the cylinder. The Smalley engine is of this design, and is illustrated in Fig. 14. On the upward stroke of the piston a charge of gas is drawn through the fuel inlet *A* into the crank case *B*. When the piston starts downward this vapor is brought under compression until the piston reaches the lowest point of its stroke, whereupon the port *C* in the piston comes into line with the port *D* in the cylinder, thus allowing the compressed gas to rush up through the by-pass *E* and through the valve *F*, into the top of the cylinder. At the commencement of the upward stroke of the piston the valve *F* closes by the spring *G*, and the gas held in the top of the cylinder is compressed and ignited; the piston is driven down and the exhaust gas passes out through the opening *H*, as usual. This motor has several advantages, not the least of which is the cooling effect on the piston of the fresh charge of cool gas rushing through it each stroke. The fresh charge coming directly in fr the head of the cylinder also serves to drive out

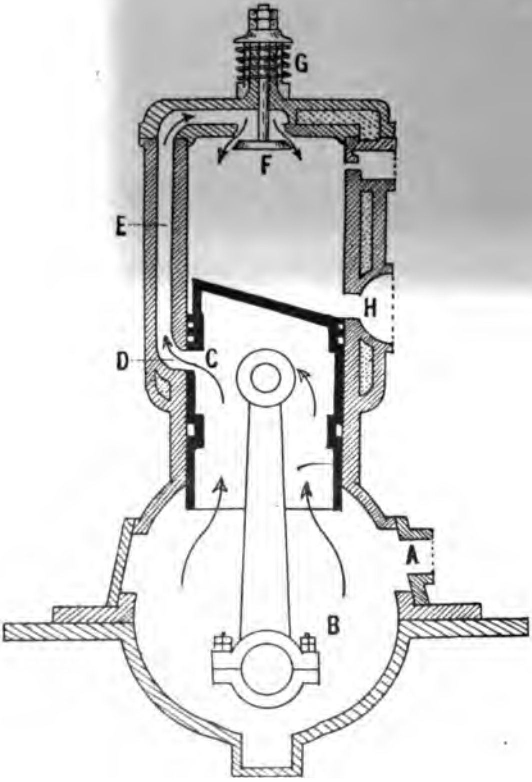


Fig. 14.—Smalley Motor

traces of burnt gas and results in a cleaner and be charge for firing. The only disadvantage in this en lies in the inlet valve in the cylinder head. This va in time will wear and cause loss of compression and will require regrinding as often as the valves of a four-cycle motor, and to the ordinary operator grinding of valves is a bugbear. Moreover, if the valve sticks, or the spring breaks, the motor is temporarily put out of service, and usually such accidents occur at the most inopportune and critical times; a similar engine with mechanically operated valve might be more satisfactory.

Several good motors of the two-cycle type are now constructed with an open base, or, in other words, without the closed crank case usually seen. This style of motor has many advantages over a closed-base engine. All the working parts of the crank, shaft, etc., are readily accessible for adjusting and oiling, and any danger of leakage and loss of compression in the base is obviated. An engine of this style of construction, made by the Powell Engine Co., is shown in Fig. 15. As will be seen by the diagram the piston *P* is hollow, and below it and above the base a compression plate *A* is placed through which the piston rod slides. Below the compression plate the piston rod is pivoted to the connecting rod *B*, at the cross-head *C*, which is a part of the same casting as the piston rod itself. On the upward stroke of the piston the gas is drawn into the space *D*, between the piston *P* and the compression plate *A*, through the inlet port *E*. On the downward stroke the gas is forced up through the by-pass *F*, to the port *G*, and thence to top of cylinder, exactly as in the ordinary two-port motor. After the explosion occurs the exhaust gases pass out through the port *H*. This motor possesses stronger compression than in a closed-base engine for forcing the charge into the

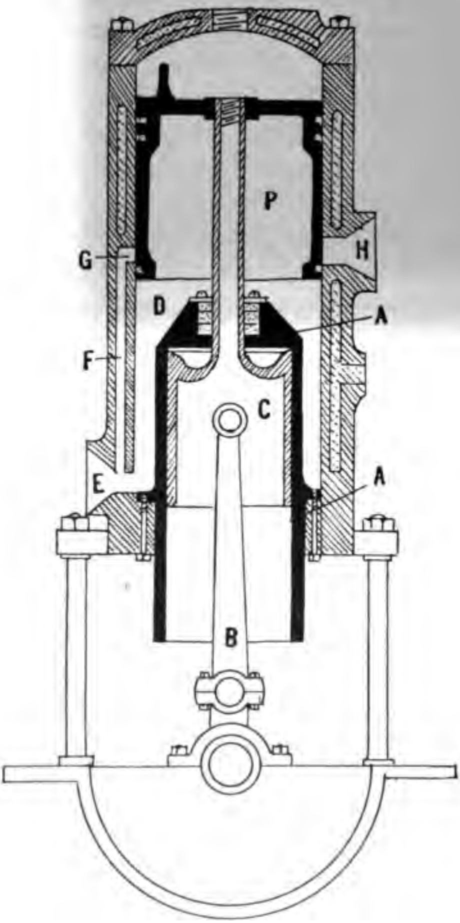


Fig. 15.—Powell Open-base Motor

cylinder, with a result that a quicker firing charge is obtained and also better scavenging of the burnt gases. The carburetor may be placed far lower than the lowest level of the cylinder, thus eliminating any danger of flooding, while the straight thrust of the piston rod and cross-head bearing do away with all side wear on the piston and cylinder walls. The cold charge of gas inside the piston also helps materially to cool the same, while the heat from the piston aids in better vaporization of the gas before its transfer to the firing chamber. The only objection to this type of motor is the additional height made necessary by the cross-head and connecting rod below the cylinder level. In stationary or marine use this is no serious objection, but for vehicle use it would necessitate a very high engine hood or small clearance beneath the shaft.

Several makers of two-port motors have also resorted to placing a throttle valve in the by-pass as shown in Fig. 16 (*T*), and while the speed and power of a motor so equipped may be controlled to some extent by this arrangement, yet as a rule I have found them rather unsatisfactory. A throttle on the fuel-mixing apparatus is far more reliable and easier to adjust. Some motors are also manufactured with a fourth, or air, port, and wonderful results are claimed for this type of motor. Undoubtedly it possesses many good points, but as a rule the fewer ports there are the more reliable the engine. To obtain the best results each port must be accurately designed and finished, and in a small engine the variation of a small fraction of an inch in the size of one or more ports will make a wonderful difference in the

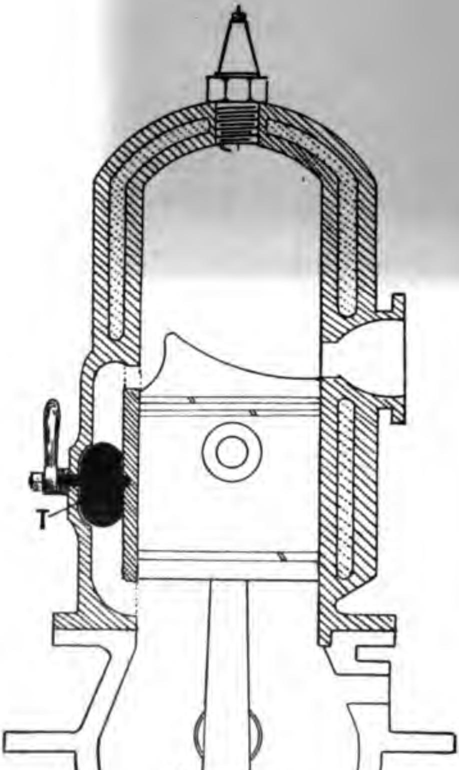


Fig. 16.—Motor with Throttle in By-pass

power and operation of the motor. Moreover, the first part of a motor that wears loose is generally the piston or the connecting rod between the piston and crank shaft. As a slight wear here causes the piston to have considerable play up and down in the cylinder, it will be easily seen that the variation in the amount of opening of each port during operation is considerable. With every port added this variation, due to looseness, increases the resulting variation of the amount of fuel admitted to the cylinder, and as the amount of play varies quite a little according to the load of the engine and its speed, it is very difficult to adjust a motor thus worn. In fact the results from a three- or four-port motor with a loose piston or connecting rod are almost as great as if the ports were rapidly but unevenly opened and closed by hand. Any one can thus readily understand why a strictly two-port motor will run more satisfactorily when old or badly worn than a three- or four-port engine.

Probably the most reliable and efficient two-cycle motor yet produced is the Elmore, which is used in the well-known Elmore automobiles. This motor, which is illustrated in Fig. 17, is entirely distinct from most other two-cycle motors and in its construction and operation it overcomes most of the objectionable features of the two-cycle engine. The figure is purely diagrammatic and represents a section of one of the four cylinders and a portion of the base cut away.

The piston of the Elmore motor differs materially from that of other motors, inasmuch as the lower half or base is much greater in diameter than the piston proper (Fig.

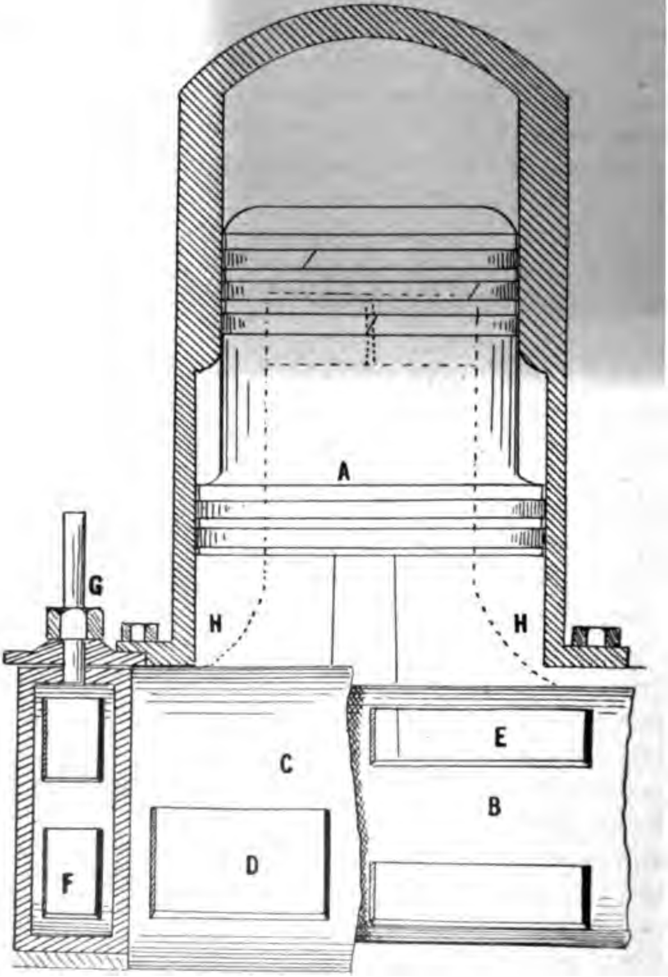


Fig. 17.—Elmore Motor

17 *A*). The up-and-down motion of this large half of the piston acts as a gas pump and alternately draws in gas to fill the lower half of cylinder or base, *H*, and forces it out under considerable pressure. When the slightly compressed gas is driven out of the base it does not at once find its way up through a by-pass and port into the same cylinder as in the ordinary motor, but, through the agency of a gas "distributor," is introduced to the firing chamber of another cylinder. This "distributor," which is the essential portion of the Elmore motor, consists of a revolving cylinder *B* almost surrounded by another cylinder *C*. The chambers thus formed are provided with long ports running lengthwise; those of one chamber opening on one side of the distributor *D* and those of the other chamber opening on the opposite side *E*. In operation the distributor is revolved within its casing by a silent driving chain from the crank shaft, each end being supported by spindles and ball bearings.

In action each lower half of a cylinder receives gas drawn through the outer chamber of the distributor. This gas under low compression is then returned to the inner chamber of the distributor, from which it is led into the firing chamber of the cylinder whose piston is just commencing the ascending or compression stroke. Compression and explosion then follow exactly as in any other engine, and the operation is repeated in each cylinder in proper order, thus giving four explosions or impulses to the crank shaft with cranks set at 90-degree angles.

It must be borne in mind that the chambers of the distributor do not extend through its entire length. The inner chamber *B* is divided at its centre, thus dividing the distributor into two equal parts. These two parts are connected by means of a by-pass *F* which is opened or closed by the operation of the throttle *G*. Until the throttle is opened half-way the two halves of the distributor operate independently, with the result that the cylinders work in pairs. When the throttle is half-opened the central control automatically opens and the power of the motor is then at once increased through all four cylinders operating alternately.

This Elmore motor, although apparently complicated, is in reality far simpler and has less parts than the ordinary four-cycle engine. Although advertised as a "valveless" motor, it is not strictly a valveless engine, for the "distributor" is actually a sort of rotary valve. The motor may therefore be considered a rotary-valve two-cycle motor. There is no doubt of the high efficiency of this engine, and its design and construction mark a great advance in two-cycle engines. The loss of base compression, unequal distribution of gas, loss or waste of fuel, and various other defects of the ordinary two-cycle engine are entirely overcome in the Elmore, and its flexibility, power, reliability, and economy of fuel are fully equal to many, if not all, six-cylinder, four-cycle motors of equal rating. In comparison with four-cylinder, four-cycle motors of the ordinary type, the Elmore is far ahead. The trouble and difficulties experienced with poppet-valve, four-cycle motors is absent in the present motor, but the revolving distributor, chains, numerous rotating ports of the distributor, and the various other parts must be perfectly timed and free from any lost motion or undue wear to work satisfactorily. These various parts of the rotating mechanism render the motor far more complicated than the regular two-cycle machine and it is therefore doubtful if this type of motor is so well adapted to the ordinary needs of the gasolene-engine user as either the regular two- or four-cycle engine. As a vehicle motor it is most efficient, and for this purpose—for which it was designed—the rotary distributor is no objection. For small boat or stationary use, however, the simplest engine is the best, and motors for this purpose should be selected which can be readily repaired, adjusted, or taken down and cleaned by inexperienced hands.

Two-cycle motors, as well as those of the four-cycle type, are usually made in either one, two, three, four, or six cylinders. The operation of a multiple-cylinder, two-cycle engine is practically the same as in a single-cylinder, but certain parts are slightly different in construction and design. In a two-cylinder motor the piston of one cylinder is on the downward stroke while that of the other is on the upward stroke, or, in other words, the cranks of the shaft are set opposite one another or at an angle of 180 degrees (Fig. 18). In a three-cylinder motor the cranks are set at 120 degrees (Fig. 19), while in a four-cylinder motor the cranks may be set at 90 degrees (Fig. 20 *A*), or at 180 degrees as shown in Fig. 20 *B*, *C*.

Three-cylinder motors have some advantages over the two- or four-cylinder machines, but they are more difficult to time correctly and either two- or four-cylinder engines are more widely used.

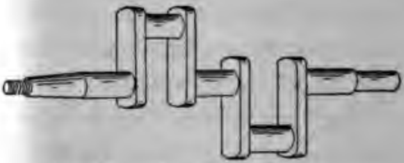


Fig. 18.—Two-throw Crank

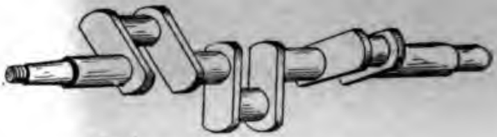


Fig. 19.—Three-throw Crank

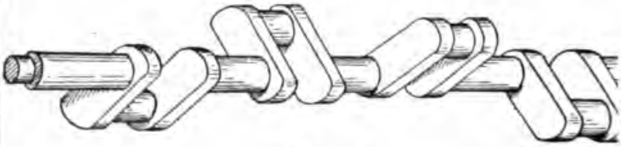


Fig. 20A.

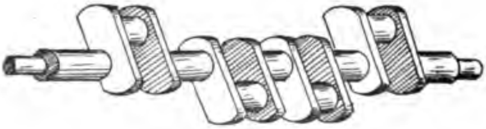


Fig. 20B.

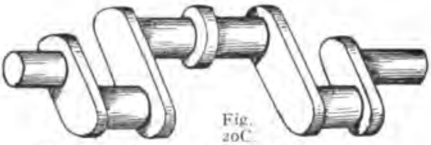


Fig. 20C

Fig. 20A–B–C.—Four-throw Crank

A multiple-cylinder motor will not deliver as much power in proportion as the same number of cylinders in separate motors, but on the other hand they run far more steadily and with less vibration than the single-cylinder engine. Moreover, they are easier to control and if one or more cylinders fail to work the engine will usually operate on the remainder, and while in action the faulty cylinders may be adjusted until all are in running order. Few multiple-cylinder engines will carry a full load when any of the cylinders fail; and as a rule such engines, as well as all but the smaller single-cylinder motors, should be provided with a clutch, or gear, so that they can be run free from a load when so desired.

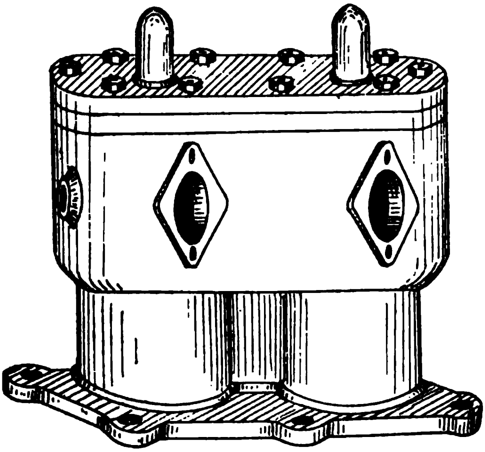


Fig. 21.—Cylinders *en bloc*

Multiple-cylinder motors have numerous disadvantages, especially for the person unfamiliar with explosiv engines or other machinery; their parts are far mor numerous than in the single-cylinder motor; they ar harder to "crank" or turn over, and if any adjustmen or regulation is wrong it is far more difficult to locat the trouble. In case of a serious trouble or breakag

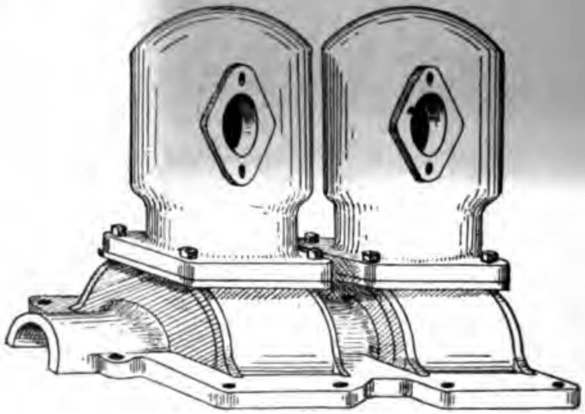


Fig. 22.—Separate Cylinders on Solid Base

a multiple-cylinder motor is more difficult to take dow than an engine of one cylinder, and in many makes th entire machine must be taken apart in order to reach break or injury in any one of the cylinders or its part Multiple-cylinder engines of the two-cycle type a made either "en bloc" with the several cylinders in o casting (Fig. 21), or are built up of several separa cylinders bolted to a single bed plate or base (Fig. 22 Each of these systems has its advantages, for while th solid casting results in a more compact and strong engine, the built-up motor is easier to take apart and repair.

For vehicle use and marine work, where considerable power is required, multiple-cylinder motors are almost universally used, but for stationary work, except where great power is necessary, single-cylinder engines give satisfactory results.

In estimating the power of motors with several cylinders the formulæ already given may be used, but the square of the bore times the length of stroke should be multiplied by the number of cylinders before multiplying by the number of revolutions; for example, to find the D.H.P. of a three-cylinder motor of 4-in. bore and 4-in. stroke operating at 500 revolutions per minute: $4 \times 4 \times 4 \times 3 \times 500 = 96{,}000$ divided by $13{,}500 = 7\frac{1}{2}$ D.H.P. It must be borne in mind that these figures are merely approximate. The *only* method for determining the *exact* power of an engine is by actual test, but the use of formulæ helps a great deal in selecting a motor, as it gives the prospective purchaser, or user, a reasonable idea of the power he may expect a motor to deliver under normal conditions when operating at the number of revolutions indicated.

CHAPTER III

FOUR-CYCLE MOTORS

To a person familiar with two-cycle motors the four-cycle engines appear extremely complicated at first. With the number of moving parts reduced to the minimum in the former, their operation and care seem easy and their mechanical construction and principle very simple. In the four-cycle motors the parts are greatly increased in number while the moving push rods, cams, gears, and springs make the engine appear a most bewildering piece of mechanism. This apparent complication has done much to prevent the adoption of four-cycle motors for light marine and stationary work, for many people seem to think a skilled engineer is necessary to operate one of these motors. In reality a four-cycle engine is very simple if we study it properly, and its care and operation are almost, if not quite, as easy as those of a two-cycle.

In fact, a good four-cycle engine requires less personal attention and can be handled more readily when at a distance or out of reach than a two-cycle, as is evident from the facility with which automobile motors are started, stopped, and handled from the driver's seat while the motor is completely out of sight and reach. Four-cycle motors are made in any number of cylinders from one to eight or more; but as the mechanism and operation are identical in each cylinder, a single-cylinder machine once understood will render any multiple-cylinder motor intelligible.

Four-cycle motors, like the two-cycle engines, consist of a cylinder, piston, base or crank case, connecting rod, shaft, and fly-wheel. In addition to these common parts it also has a number of other moving pieces whose function is to operate the valves. These parts are known collectively as the *valve mechanism*, and as they seldom require attention their complicity need cause no worry. As in two-cycle motors, there are various styles and variations in four-cycle types. The commonest form in use is known as the *poppet-valve* or *mushroom-valve* engine. In this motor the valves for the inlet of the vapor charge and for the outlet of the exhaust are mushroom-shaped, consisting of a rounded or flat disk-like head attached to a cylindrical shaft or spindle called the *valve-stem* (Fig. 23). Nine-tenths of the four-cycle motors in use to-day employ this style of valves, and their variation consists mainly in the method employed to operate the valves or in the location of the valves in the cylinder casting. As the valves operate but once for each complete revolution of the crank, it is necessary to attach the valve mechanism to some form of gear with a ratio of two to one, or, in other words, to so reduce the speed of the shaft operating the valves that it makes

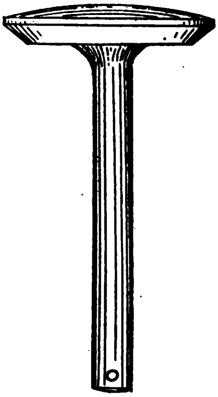


Fig. 23.—Tappet Valve

but one revolution to every two revolutions of the
shaft.

This may be accomplished by either cog-
worm-gear, or sprocket-wheels and chain. Pra
every form of gear is used by the various makers
cycle engines, but the worm- or screw-gear, or th
wheels with slanting teeth known as the "helical
are the most satisfactory and are now generall

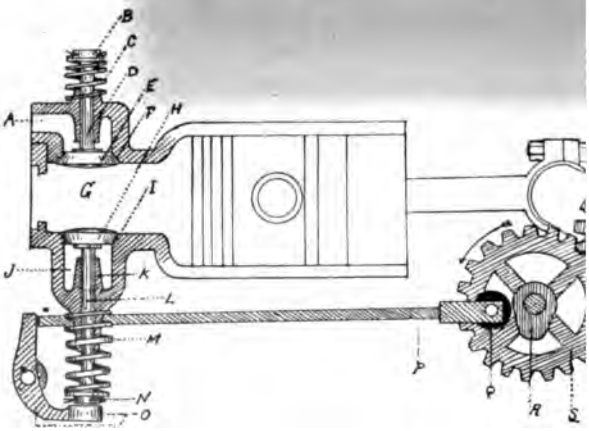
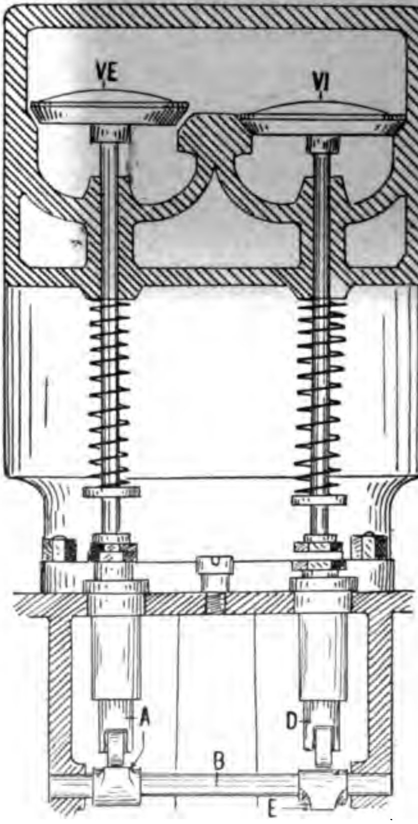


Fig. 24.—Valve Mechanism. Cadillac

In the earlier designs, as well as in many modern
plain cog-wheels or *spur-gears* are used. Thes
very well, but wear faster and are far more nois
the screw, or helical, forms. In Fig. 24 the valve
nism of a motor using the spur-gear is shown.
illustration, *T* represents the cog-wheel attached
engine shaft, and *S* a gear of twice the size of *T*, at
to a separate shaft. Keyed to this shaft is a

urns against the roller *Q* pivoted in the push- As the engine shaft revolves in the direction d by the arrows, the wheel *S* revolves at half ·d and in the opposite direction. When the cam against the push-rod *P*, it pushes it outward the bell crank *O*. This in turn presses the em *L* upward and lifts the outlet valve *H* from *I*, thus allowing the burnt gas to escape. The *M*, acting against the valve foot *N*, serves to .e valve firmly on its seat and to cause the push- :ollow back against the cam. In this motor it ›een that the inlet valve *E* is not connected with ›e gear or other mechanism, but is provided with *C*, which serves to keep it firmly seated. This is ıs an ***automatically operated valve***, while the outlet ; a ***mechanically operated valve***. Many motors t in this way, for the suction of the piston on the troke is sufficient to act on the inlet valve and to open long enough to admit the proper charge

›ugh several excellent motors utilize this sys- t they have many disadvantages. The springs se their strength and liveliness, causing the) open slowly or unevenly, or else to open too and seat too lightly. In one case the charge d is insufficient, while in the other case the com- gases are liable to escape backward into the 1 cause loss of power and back-firing. Moreover, of a leakage around the piston, or in the firing r, the suction of the piston may prove unequal ısk of opening the inlet valve far enough or long enough to admit a full charge. It is far better to operat both inlet and outlet valves by mechanical means a illustrated in Fig. 25, in which the exhaust valve i



ig. 25.—Mechanically operated Valves

actuated by the push-rod and cam *A*, attached to tl cam-shaft *B*, and the inlet valve *VI* is also operated l push-rod *D* through the cam *E*, on the same .h the exhaust-cam, but set at an angle with it. method there is no chance of the inlet valve on its seat or failing to seat and if the cams s are set properly a uniform and correct charge ιys be admitted to the cylinder at exactly the

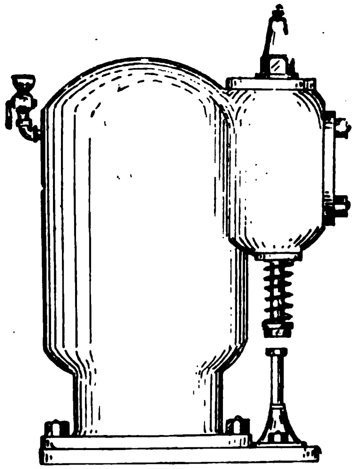


Fig. 26.—"L"-head Cylinder

ıe. This is a very common and widely used our-cycle motor. The exterior form is shown in It is known as the *T-head* or *L-head* type from ›e of the cylinder and valve chamber. More :ill is the *valve-in-head* type in which the two re located in the head of the cylinder instead ›ffset, or separate, chamber. This type (Fig. 27) y advantages over the T-head type, and is now ʳ acknowledged to be far more effective and economical. The two valves being set in the cylinder head allows the interior to be machined smooth and free from corners, or pockets, where burnt gas might accumulate. The incoming charge also serves to thoroughly fill the chamber and the outgoing exhausted gas is more thoroughly discharged. The cylinder head and

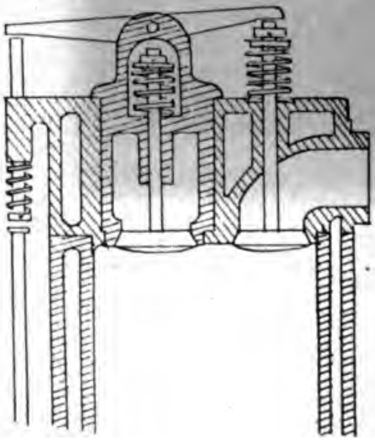


Fig. 27.—Valves in Head

valve seats, as well as the piston head, are also greatl cooled by the fresh charges of gas, while the arrangemen of the valves allows the greatest cubical capacity of th cylinder with the least area of surface. Most of th various makes of poppet-valve motors vary principally i the valve mechanism, style of gear, and other mino details; but motors with rotary and sliding valves hav now come into use and in their perfected state giv results equal to, or even better than, the best poppet-valve engines.

The *Knight Sleeve Valve* motor is a comparatively recent invention, but has won its way rapidly to popularity and success by its remarkable performances in several well-known makes of automobiles. In this engine, which is shown in Fig. 28, the piston is surrounded by two cylindrical sleeves, or tubes, one within the other and both between the piston itself and the walls of the cylinder proper. The diagram (Fig. 28) shows a section cut away to show the piston *P*, the inner sleeve *S*, and the outer sleeve *O*, while *C* represents the cylinder walls. The two sleeves are connected with connecting rods and eccentrics to the gear shaft, as illustrated in Fig. 29, in which *P* represents the piston, *S* the inner sleeve, *O* the outer sleeve, *C* the cylinder, *A* and *B* the connecting rods to the two sleeves, and *D* the eccentric attached to the gear shaft *E*. The gear is in the form of a sprocket-wheel *E* connected with the main shaft by a roller chain *F*. In the sleeves are openings, or ports, *G*, *H*, which are alternately brought opposite the exhaust and inlet ports in the cylinder, *I*, *J*. In operation the sleeve *O*, sliding past the sleeve *S*, brings the ports *G*, *H* opposite one another as well as in line with the inlet port *I*. This occurs on the downward stroke of the piston and the charge of gas is thus drawn into the cylinder as in Fig. 30. On the upward or compression stroke, the sleeves move to the position shown in Fig. 31, in which the ports *G*, *H*, *I*, *J* are all out of line and thus closed against the escape of gas from the cylinder. The charge is compressed and fired on the limit of this upward stroke as usual and the piston driven downward. Near its lower limit two of the ports are again brought opposite the

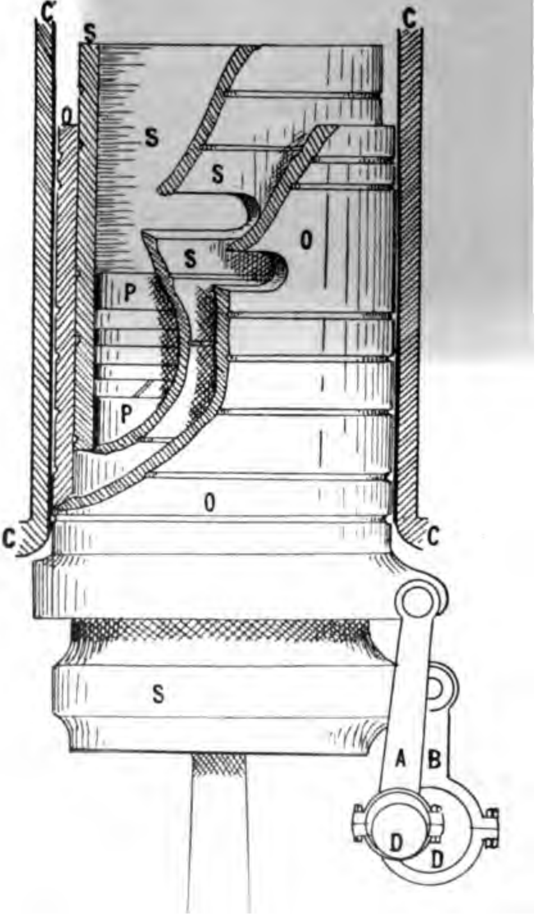


Fig. 28.—Knight Sleeve-valve Motor; Piston and Sleev

outlet port and the burnt gas is forced out through the exhaust on the upward return stroke as in Fig. 32. This Knight type of motor is practically noiseless in operation, has little wear, and obviates all trouble with badly fitting or worn valves or weak springs. It also provides an ample and uniformly sized opening for both intake and exhaust of gases, and tests appear to prove that it actually improves in efficiency with age and use. The sliding sleeves must of course create quite an appreciable amount of friction, although it is doubtful if this is much

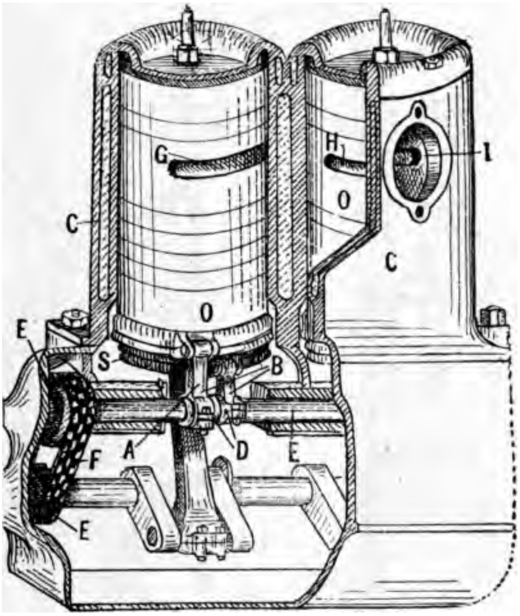


Fig. 29.—Knight Sleeve-valve Motor; General View

greater than the combined friction on the variou push-rods, valve stems, springs, and other parts poppet-valve motor. Lubrication is very essentia motor, for if allowed to run dry, or to overhe

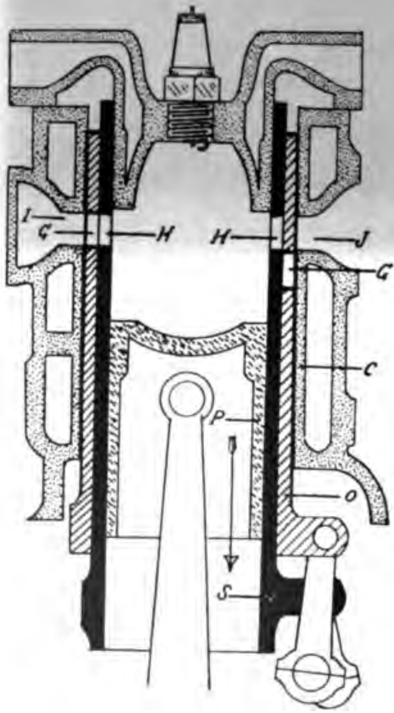
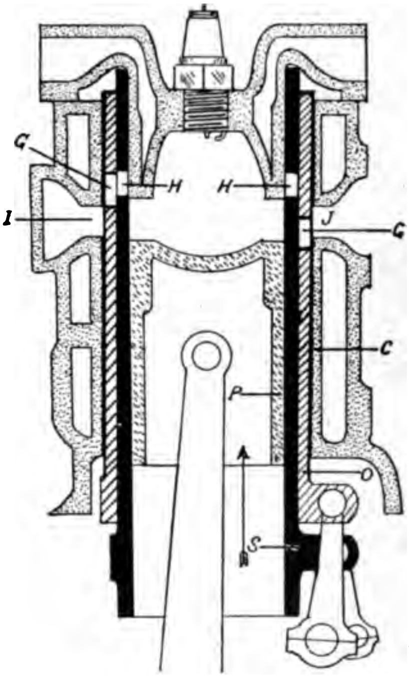


Fig. 30.—Knight Sleeve-valve Motor; Section to show O

friction on the sleeves becomes enormous and cutting and extreme wear soon result.

Rotary-valve motors are now being made whic excellently; and the Reynolds motor, illustra

s proven a most practical and reliable engine
e. The illustration represents a view of the
ion of the cylinders with the rotary valves *A*
cylinders *II*, *III*, and *IV*, and removed from



night Sleeve-valve Motor; Section to show Operation

The valves consist of circular disks *A*, *A*,
in recesses machined in the cylinder heads
re provided with openings *B*, which correspond
ith openings in the cylinder heads, *C*, *D*. The

stems of these disk valves are connected toget
top of the cylinders by means of spiral or helical g
which are in turn operated by a geared vertical
connected at its lower end with a gear on the

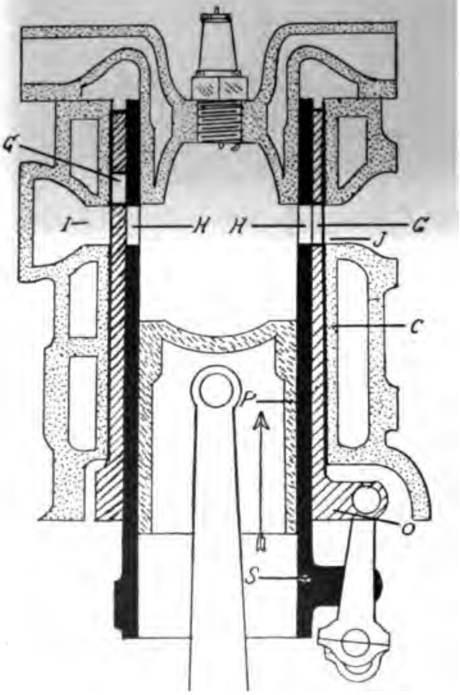


Fig. 32.—Knight Sleeve-valve Motor; Section to show O

shaft. On the suction stroke the valves are
through the action of the gears, and the opening
valve moves into line with the corresponding in
C, thus allowing a charge of gas to be drawn i

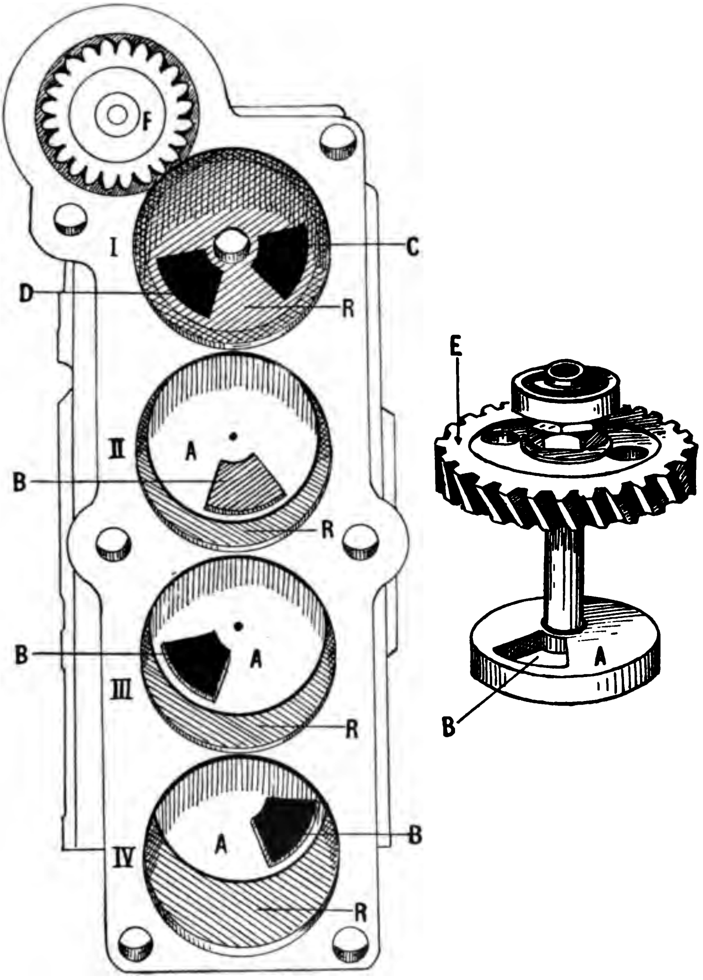


Fig. 33.—Reynolds Rotary Valve Motor. Top of Cylinder and Valve

cylinder (position *IV*). On the upward or comp
stroke the valve continues in its rotation and
the inlet port *C* and permits proper compression
charge which is fired in the usual manner (positio
After the explosion the piston on its downward
revolves the shaft with its connecting gears an
rotates the valves until the opening *B* uncove
exhaust port *D*, through which the burnt gases are
by the returning piston (position *III*). This m
too new to judge of its ultimate future or general ad
but it possesses many advantages over either the p
valve or sleeve-valve types, and where it has bee
it has given most highly satisfactory results.
exhaust opening being a trifle larger than the
allows a full and perfect scavenging of the bur
while the uniform and accurate opening of th
and exhaust ports is fully equal to the same
obtained in the Knight motor. The valves be
bronze form their own bearing surface on the i
the cylinders, while the constant rotary motion a
fact that they are always firmly seated preve
formation of carbon deposits. Of course there i
wear of the valves against their seats, but adju
for taking up this small amount of abrasion is pro

There is comparatively little friction and the
are provided with ball bearings at the upper end
stems, while the action of the spiral or helical g
positive, accurate, and practically noiseless. The
gear, vertical valve driving rod, and valve gears
enclosed, giving the motor a very neat and clean a
ance, and yet all are readily accessible. Although

tofore used principally as a marine engine, yet there is no reason why the rotary-valve motor should not give equally good results in stationary or vehicle use, and automobiles are now being equipped with this motor which will doubtless prove most successful.

Another rotary-valve engine which has recently appeared on the market is the Russell motor manufactured by The Silent Valve Co. of America. In this engine the rotating valves are conical in form and through a special arrangement of driving yokes and springs the valves automatically adjust themselves for

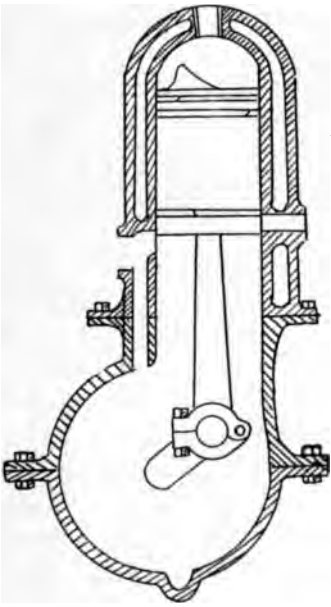


Fig. 34.—Offset Cylinder Motor

wear or expansion. Doubtless many other designs rotary- and slide-valve motors will soon appear, for tl present tendency of design is to improve upon the o poppet-valve mechanism. For general use, however, it doubtful if this type of valve can be greatly improv upon.

Four-cycle motors vary considerably in design a arrangement of parts with different makers. The motors, as well as those of the two-cycle type, are oft made with the cylinders offset (Fig. 34), a system whi is supposed to overcome the tendency to a dead cent and which is used to a considerable extent on vehi motors but has never become general on marine stationary engines, but is a special feature of the we known Ferro engines. Motors with the cylind horizontal and opposed or opposite are also wid used, and this arrangement has many advantages o the vertical-cylinder motors and has been adopted many makers of marine, vehicle, and stationary engin These motors are very compact, light, and powerf and the balanced method of construction gives a mi mum vibration owing to the impulse from the oppos pistons overcoming the jar and rotary tendency ordinary motors (Fig. 35). For small vehicles su motors are excellent and in many classes of boats th are far more convenient than the regular vertical engin Their operation, as well as that of certain "V-shape models, is practically the same as in the ordinary fo cycle motor, but in the opposed-cylinder type the t cylinders may be adjusted so that the explosion in t two cylinders occurs alternately, thus giving an impu every revolution as in a two-cycle motor. Multiple-linder, four-cycle motors are made in from two to t or more cylinders, but in the four-cylinder machine

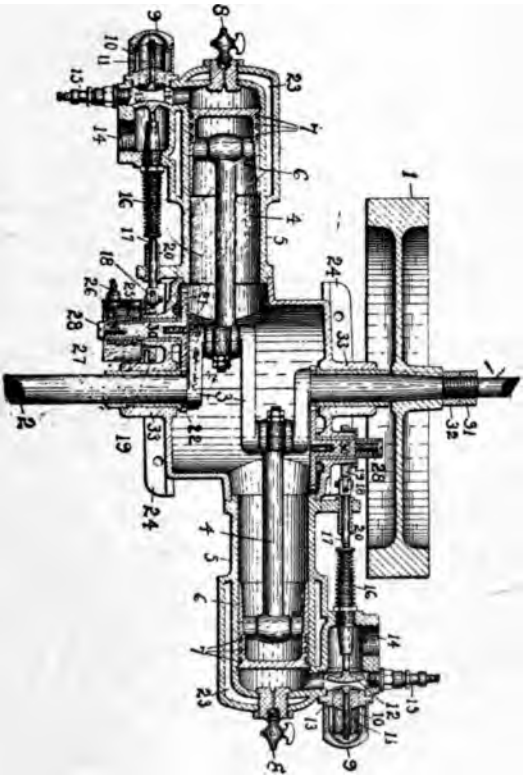


Fig. 35.—Opposed Cylinder Motor

the cranks are set at an angle of 180 degrees and are commonly constructed with the two central cranks close together without a central bearing, or with a very small one, thus allowing the two middle cylinders to be more closely placed and saving considerable space (Fig. 20, *B*, *C*). This method is possible in a four-cycle motor as the crank case is open and is one continuous chamber from the front to rear cylinder. In the two-cycle motors the crank cases are separate and closed and it is therefore necessary to have each crank separated by a gas-tight bearing on the shaft.

The fact that four-cycle, four-cylinder motors have cranks at 180-degree angles renders such motors more irregular in the pressure exerted on the shaft and causes more vibration than either three- or six-cylinder motors of the same type; and the latter are rapidly taking the place of the four-cylinder engines where silent, steady operation is desired.

In addition to the ordinary types and practical forms of both two- and four-cycle motors, many original and remarkable variations in design and construction are frequently patented and offered for sale. Such designs are mainly freaks, and while some of them—such as the true rotary motor—may eventually be perfected and become practical for every-day use, yet at the present time a satisfactory rotary gasolene engine is unknown. Among these freak designs is the type illustrated in Fig. 36. In this engine the explosion is balanced by the motion being transmitted through the levers *D*, *F* to the cranks *G*, while the explosion occurs between the two pistons *H*, *H*, thus driving the levers *D*, *D* by the connecting rods *E*, *E*. While this motor actually works, yet it has no advantage over any other opposed-cylinder motor and has innumerable disadvantages, not the least of which is the extra weight of the various moving parts. All these levers, cranks, etc., also add a great deal to the friction, while the loss of power through worn bearings and lost motion more than offsets any possible advantages the design may possess. Numerous motors have been designed in which an impulse occurs alternately at opposite ends of a piston, thus giving an explosion for every stroke of the piston. Motors of this design are expensive to construct and the difficulties in properly cooling and lubricating the connecting and piston rods are very great. In very large sizes such engines are in use, however, and give excellent satisfaction. A detailed description is not necessary, as the operation of these motors is practically identical with single-acting engines, although in some designs the mixture of fuel and air is forced into the compression chamber by the action of a pump cylinder operated by an eccentric or cam.

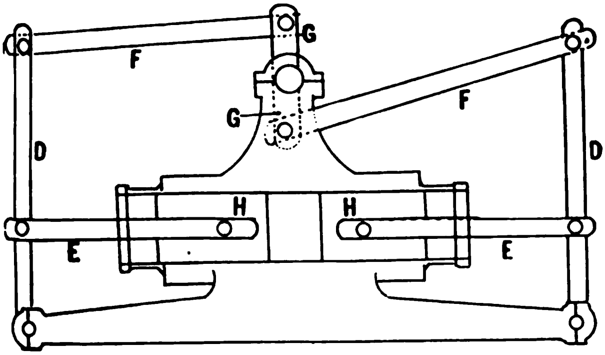


Fig. 36.—Freak "Balanced" Motor

Both two-cycle and four-cycle motors are frequ made in horizontal form (see Fig. 37) for stationary For such purposes a horizontal engine is often sup to a vertical machine, as it gives a wider, longer, more stable bed in proportion to the height from f and in addition it permits of the use of large and h

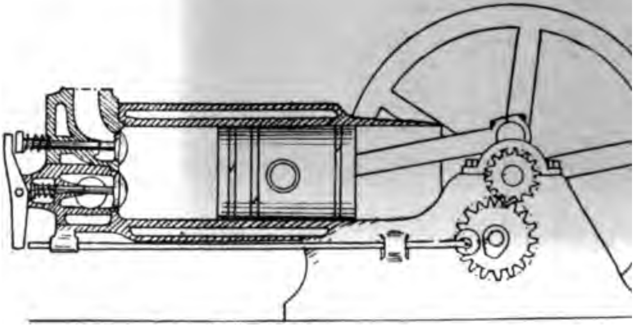


Fig. 37.—Horizontal Motor

fly-wheels which give steadier running with less v tion and decrease to a minimum the liability of motor stalling when operating under a heavy The operation of a horizontal engine is in no ma different from that of a vertical motor of the same t and hence a further description is not necessary.

CHAPTER IV

RTS OF TWO-CYCLE MOTOR.—PARTS OF FOUR-CYCLE MOTOR.—COOLING METHODS; WATER- AND AIR-COOLED MOTORS.—DESIGN AND CONSTRUCTION OF MOTOR PARTS; CYLINDERS, PISTONS, PISTON-RINGS, CONNECTING-RODS, CRANK-CASES, JACKETS, SHAFTS, COUNTERWEIGHTS, BEARINGS, GEARS, CAMS AND VALVES, FLY-WHEELS; ACCESSIBILITY.

BY reference to the following figures and explanations cuts it will be seen that the number of parts in the ro- or four-cycle engine is not very great, but as many the smaller parts, such as the various bolts, screws, ts, pins, springs, washers, etc., are duplicated many mes, the actual number of pieces used in an engine very large. While the main parts, such as cylinder, haft, piston, connecting-rod, piston-rings, crank-case, y-wheel, etc., are identical in either type of motor as far s actual numbers go, and in multiple-cylinder engines re merely duplicated for each cylinder, the four-cycle motor has in addition numerous pieces of mechanism connected with the valve and cam shaft that are wanting in the two-cycle motor. The illustrations represent motors of both the water-cooled and air-cooled jump-spark type. Air-cooled motors have fewer parts owing to the absence of pump, water pipes, check valves, etc. (Fig. 39), while the make-and-break system of ignition requires more parts than the jump spark (see Fig. 40). All gasolene and internal-combustion engines require cooling of some sort to prevent overheating, warping,

PARTS OF TWO-CYCLE MOTOR

(Jump Spark, Water-cooled)

A, Cylinder
B, Water Jacket
C, Piston
D, Piston Rings
E, Piston Pin
F, Connecting Rod
G, Crank Case or Base
H, Bearing Head or End Plate
I, Main Bearings
J, Connecting-rod Bearings
K, Piston-pin Bushings
L, Counterweights
M, Oil Duct to Connecting-rod Bearings
N, Crank
O, Crank Shaft
P, Timer Gears
Q, Gear Cover
R, Timer Shaft
S, Timer
T, Fly-wheel
U, Fly-wheel Locknut
V, Fly-wheel Key
W, Ball Thrust
X, Pump Eccentric
Y, Pump Plunger
Z, Pump Packing Gla
PK, Pump Packing
PB, Pump Body
CV, Check Valves
DC, Drain Cock
FC, Firing Chamber
SP, Spark-plug Hole

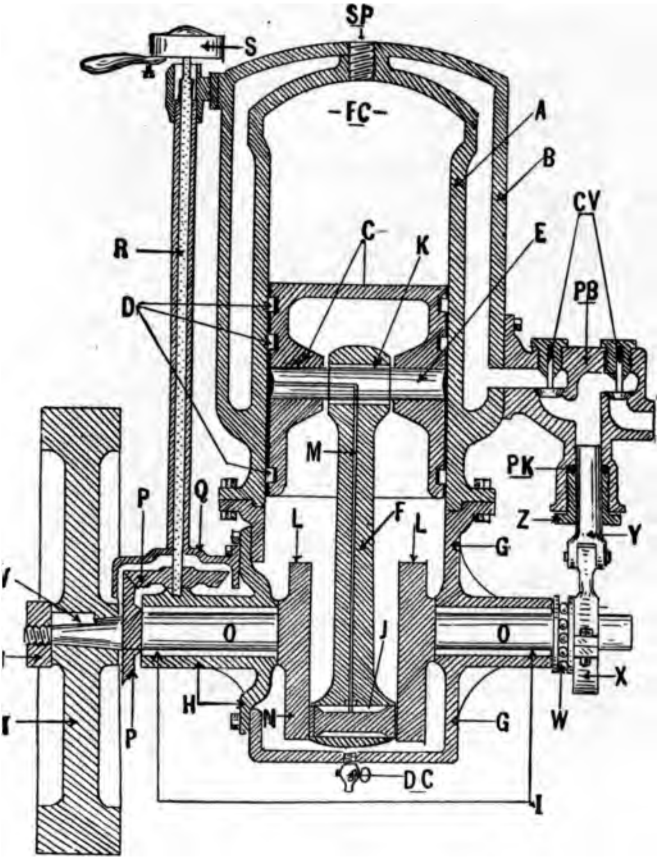


Fig. 38.—Parts of Two-cycle Motor
Water-cooled, Jump Spark

PARTS OF FOUR-CYCLE MOTOR

(Jump Spark, Air-cooled)

A, Cylinder
AH, Cylinder Head
B, Radiating Flanges
C, Piston
D, Piston Rings
DC, Drip Cock
E, Piston Pin
F, Connecting Rod
FA, Connecting-rod Cap
FC, Firing Chamber
G, Crank Case
GA, Base Plate
H,
I, Main Bearings
J, Connecting-rod Bearings
K, Crank Pin
LL, Counterweights
M, Valve Driving Gear
N, Crank
O, Crank Shaft
P, Timer Gears
Q, Valve-gear Shaft
R, Timer Shaft
S, Timer
SP, Spark Plug
T, Fly-wheel
U, Fly-wheel Locknut
V, Fly-wheel Key
W, Ball Thrust
X, Valve Gear
Y, Valve Cam
Z, Valve Push-rod Roller
ZA, Valve Push-rod
VE, Exhaust Valve
VEF, Exhaust-valve Foot
VEG, Exhaust-valve Stem Guid
VES, Exhaust-valve Stem
VET, Exhaust-valve Spring
VI, Inlet Valve
VIG, Inlet-valve Stem Guide
VIS, Inlet-valve Stem
VIT, Inlet-valve Spring
IV, Inlet
EX, Exhaust

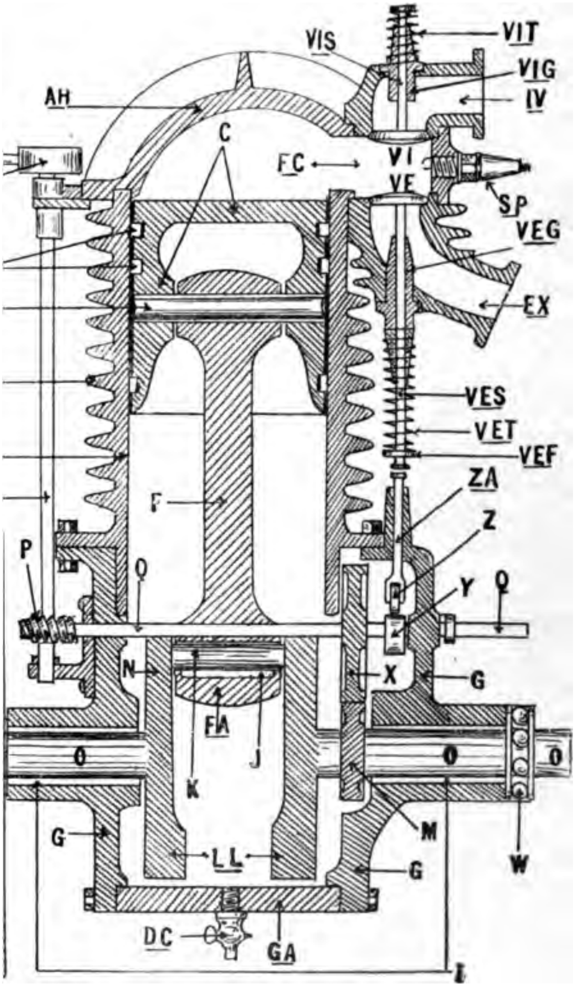


Fig. 39. --Parts of Four-cycle Motor Air-cooled, Jump Spark

EXPLANATION OF FIG. 40

(Parts of Two-cycle Make-and-break System)

A, Spark Plug
B, Movable Electrode
C, Electrode Rocker Arm
D, Electrode Spindle
E, Electrode Spindle Bushing
F, Angular Dog
G, Trip Adjusting Screw
H, Plunger
I, Plunger Thimble
J, Plunger Spring
K, Rocker-arm Spring
L, Dog Spring
M, Slide Bar
N, Slide-bar Guide
O, Ecccentric and Eccentri
P, Pump
Q, Pump Plunger

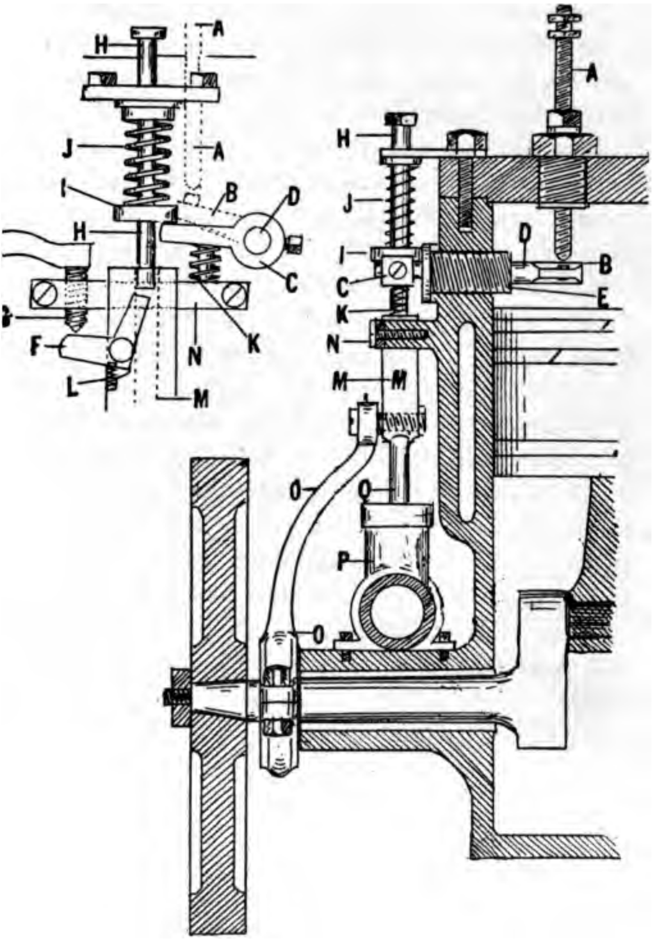


Fig. 40.—Parts of Make-and-break System

and seizing of the cylinders and pistons, and this is accomplished either by means of air forced past the cylinders by a fan or blower, or by water circulated between the cylinder proper and an outer covering known as the water jacket (Fig. 38 *B*).

Air-cooled motors are usually provided with flanges of thin metal cast on the cylinders (Fig. 39), to aid in radiating the heat, and are little used in comparison with water-cooled motors. In marine use the water-cooling system is used invariably, as it is very easy to connect the pump to an outlet and inlet and thus keep fresh, cool water circulating through the jacket while the motor is operating. When used for vehicle or stationary use a radiator or similar cooling system is used, through which the water is forced by the pump, and which, by numerous thin flanges or by thin-walled compartments of small capacity, tends to radiate heat and thus cool the water. In stationary engines a large tank, or hopper, is usually sufficient to cool the water through exposure of a large surface to the air. A sheet of cloth, wire gauze, or a perforated plate is often used to aid in cooling the water from stationary motors, as the hot water from the engine flowing over this is rapidly cooled by radiation of heat from the large surface exposed to the air.

Ignition of either the jump spark or make-and-break spark may be used in gasolene motors and as far as efficiency is concerned there is but little choice; the make-and-break system is electrically simple and mechanically complicated, while the jump-spark system is just the reverse electrically complicated and ıically simple. Ignition systems will, however, lt with in detail in a following chapter and are entioned here in connection with the various parts motors.

actual value, life, and power of a motor depend as much upon the quality of material used and ıken in the construction of its various parts as ts design and proportions. The cylinders are ›nly made of fine-grained cast iron, and after to the proper size should be ground to a mirror and fitted to within of an inch. The piston ıry considerably in shape oportion with different and types of engines. ıe general principle of ıction is the same, and on is principally used in g them. A perfect-fitting is essential to a good for if too loose the ession will be lost, whereas too tight, it will bind hot and score the cylwalls or prevent the from operating. It is ıary to test all pistons linders by limit gauges; these gauges is 1/2000 of an inch oversize, the other ne amount undersize, and if the parts fit the underuge or fail to fit the oversize gauge they should be

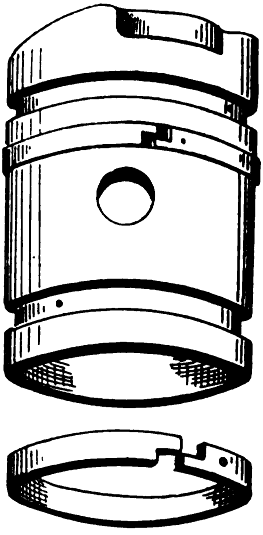


Fig. 41.—Piston and Piston Rings

discarded. The piston should not fit the cylinder too snugly, however, for allowance must be made for expansion when hot, and in order to allow for this and yet to retain gas under compression, piston rings are provided. These rings are made of cast iron and are turned and faced on a lathe, ground on the sides, and are then cut, clamped together, and ground on the faces. They are made eccentric,—thicker on one side than the other,—and are cut with a diagonal or lapped joint on the thinner side. The rings may be two, three, or four in number and are placed in grooves on the piston and are usually pinned in position (Fig. 41). The rings are slightly compressed when the piston is inside of the cylinder and their tendency to expand keeps them pressed firmly against the cylinder walls, thus forming a gas-tight joint.

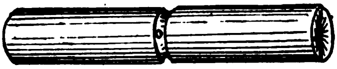


Fig. 42.—Piston-pin

The connecting-rod may be either of steel or bronze, and may be either cast or forged. The upper end, which fits inside the piston, is held in place by a hardened pin passing through the piston from one side to the other and known as the piston pin (Fig. 42). There are various methods of fastening this pin in place, but set-screws within the piston (Fig. 43, *S*) are perhaps the most satisfactory. Some makers bush the pin where it fits the piston walls and fasten the connecting-rod to the pin (Fig. 44), while others fasten the pin to the piston and provide a bearing surface for the connecting-rod y placing a bronze bushing between the pin and ting-rod (Fig. 45). The latter system is preferable bviates any danger of the pin working endwise ɔring the cylinder walls. The lower end of the ting-rod is split, or cut, through the centre of the ıred for the crank shaft, and a babbitt, or bronze, ; fitted in place and the two parts clamped :r around the crank shaft. There are various ls of fastening the bottom cap to the rod proper,

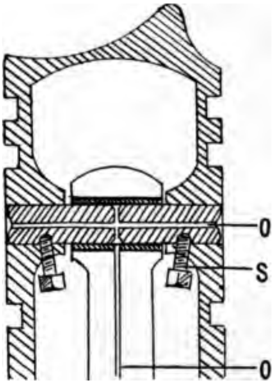


Fig. 43.—Piston-pin held by Set-screws

ıinge on one side and cap-screw with double nuts other is widely used (Fig. 46). Other makers loose cap held to the rod by screws on either side, ıile this method allows of finer adjustment, it is convenient as the hinged cap (Fig. 47). Crank ıay be cast from iron, steel, aluminum or other and may be made either solid, with one end ıble (Fig. 48); with split base (Fig. 49); with both bearings or end plates separate (Fig. 50); or the up portion of crank case and cylinder may be cast in piece with a separate cylinder head held in place by b (Fig. 51); or a combination of two or more of the ab

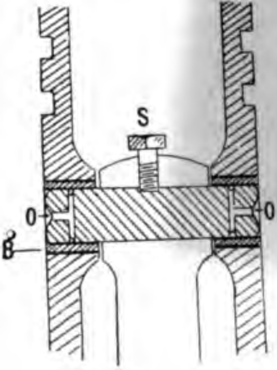


Fig. 44.—Piston-pin bushed in Piston

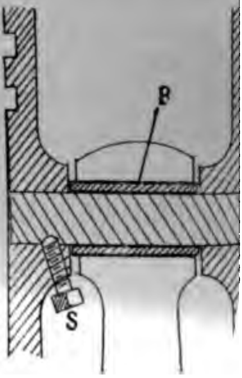


Fig. 45.—Piston-pin bu in Connecting-rod

may be used. In either case all joints should be t and faced true and smooth and thin gaskets of or similar packing, placed between the ground s

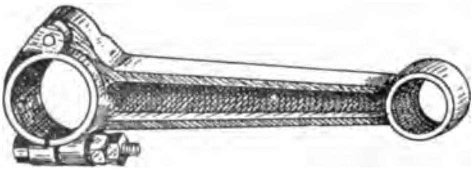


Fig. 46.—Connecting-rod with Hinged Cap

Crank cases are commonly furnished with plates on the sides (Figs. 50, 51, *H*), and these of ample size to permit tightening or adj onnecting-rod bearing without taking down the motor; ıany motors are made in which the hand-hole plates re so small that they are absolutely useless. Of course, in four-cycle motors, the base being open and the entire side plates removable, there is no trouble in getting at the crank shaft.

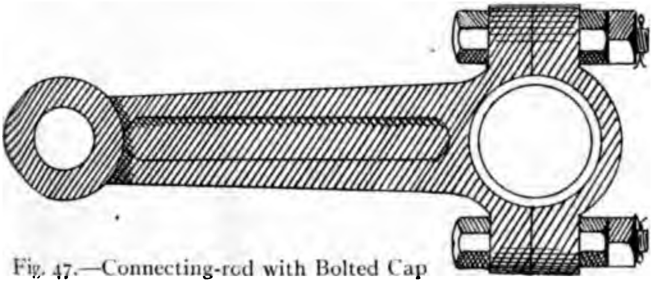


Fig. 47.—Connecting-rod with Bolted Cap

In small-sized motors it is often easier to remove the cylinder to reach the piston and crank shaft than to attempt working through a hand-hole in the base, but in large-powered and heavy motors the hand-holes are

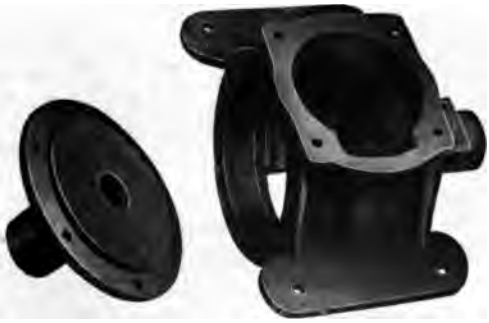
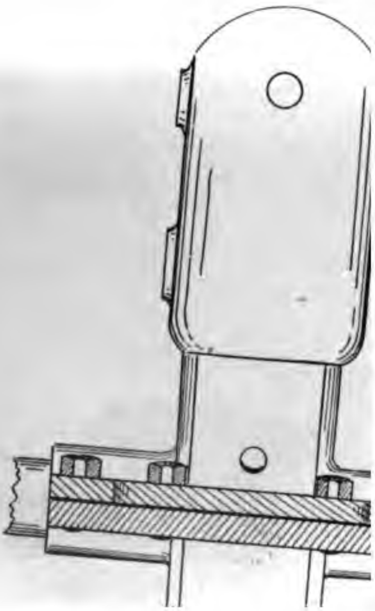


Fig. 48.—Base with One End Removable



(Fig. 52). This method is very satisfactory where fresh water is used for cooling, but for salt-water use it is not advisable, as the salts in the sea-water set up galvanic action between the copper jacket and the iron cylinder and this soon eats away the cylinder and causes rapid corrosion.

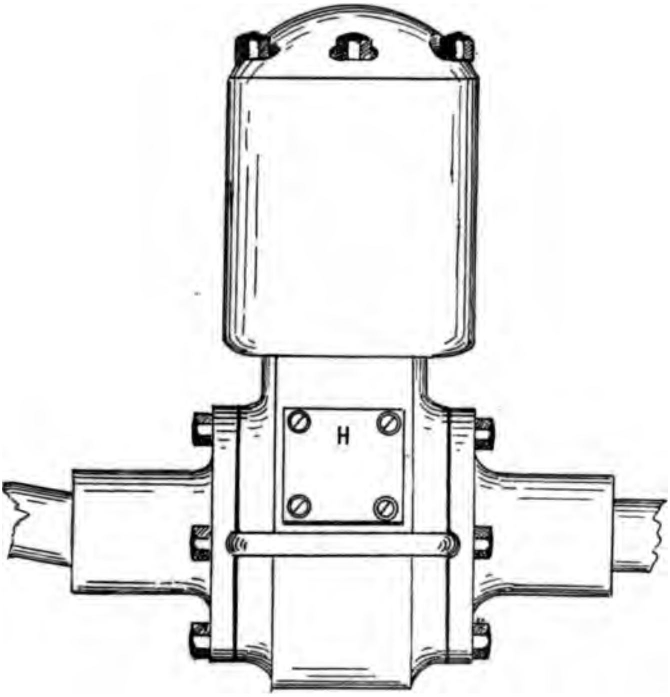


Fig. 50.—Both Ends of Base Removable

Crank shafts are perhaps too often neglected in the smaller and cheaper motors, and even in many of the

larger sizes they are not given as much care an
as they should have. Crank shafts bear all
and pressure of the explosive impulses an

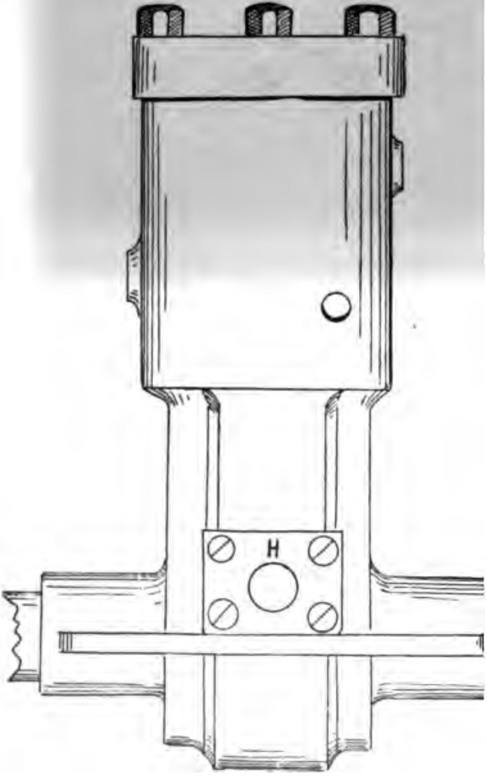


Fig. 51.—Cylinder with Separate Head

transmit all the power to the machinery; t
therefore be designed with a large excess of st
should be forged from the highest grade of st

hearth .35 to .45 carbon steel is excellent material, and after forging into shape it should be annealed, which relieves the strain from forging and renders the steel tough and strong. They should then be machined to within 3/1000 of an inch in size, and finally ground to a mirror finish, where the bearings are to fit. Many otherwise good motors have cranks without counterbalances, but these are most essential to single-cylinder

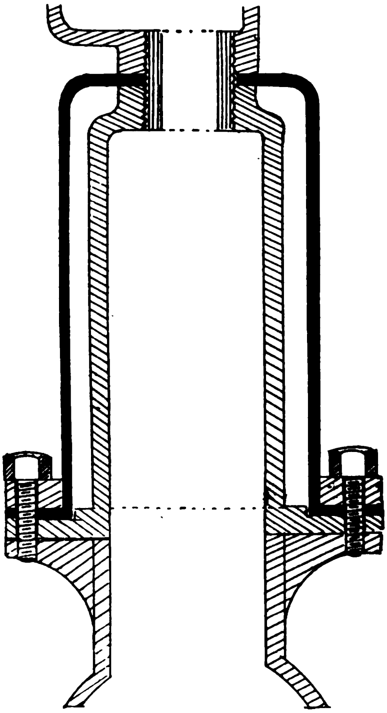


Fig. 52.—Water Jacket Clamped On

motors if smooth running and lack of vibration are desired. There are many methods of fastening counterweights to crank shafts, some of which are shown in Fig. 53. Malleable-iron weights fitted to the crank and dowelled and riveted answer very well and are widely used (Fig. 54). This is the method adopted by the Gray Motor Co. Bearings are most important parts of a motor, and various materials are used by different makers. Babbitt, bronze, white-bronze, and various special alloys are utilized, and each has its advantages and disadvantages. Babbitt is excellent, if of very high grade, but will melt and cut badly if improperly lubricated or overheated. Bronze will wear well and will stand considerable heat, but will cut and injure the shaft or other moving parts if allowed to run dry or wear loose. Whatever material is used, the fit should be perfect and the bearings so constructed that they are easily removable and interchangeable. The Gray Motor Co. uses a very high grade special babbitt, and the main bearings are very long and so constructed that they are removable

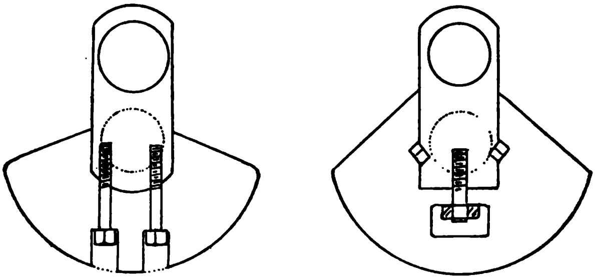


Fig. 53.—Methods of Fastening Counterweights

ıd interchangeable in a few moments (Fig. 55). In a vo-cycle motor the size and length of the main bearings e very important, for if worn or loose the crank com- ession will be lost and the motor's efficiency destroyed. Gears, timer parts, and all water connections on marine

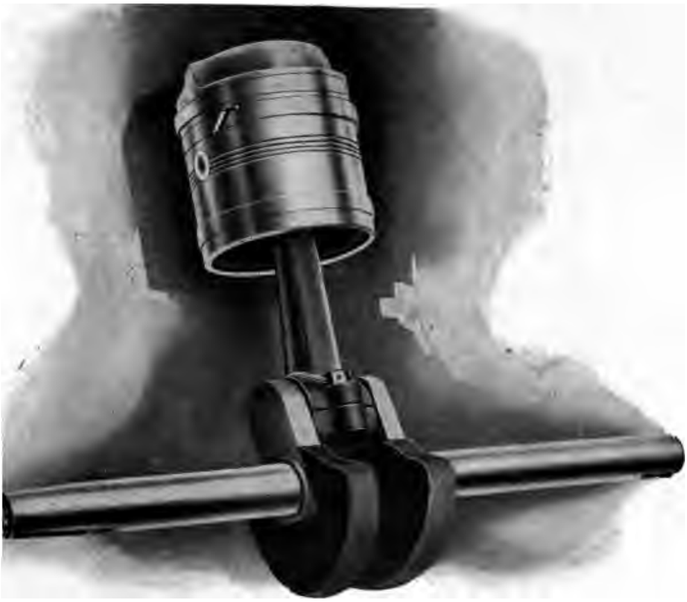


Fig. 54.—"Gray" Counter Weights

ıotors should be of bronze, or similar metal, to prevent ıst and corrosion; and if quiet-running gears are desired ıey should either be made in pressure die moulds from earing metal or should be made with fibre or rawhide ıserts or with slanting or helical teeth (Fig. 33). The articular kind of gears used depends largely upon the

are cast in special moulds and are
tons' pressure. Other makers

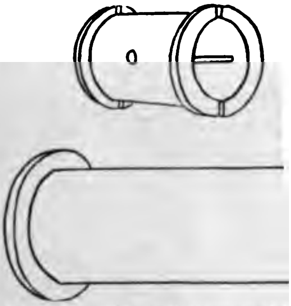


Fig. 55.—"Gray" Removabl

results by using fibre inserts in the
great care in cutting all gears on sp
insure the utmost accuracy.

Cams for operating the valve mec
motors should be of case-hardened

· motor-owner to replace all such valves with new ones ged from the best quality steel.

ccessibility in a motor is a very important matter l one that is all too often overlooked. Many motors of ellent design and most careful construction are so embled that in order to get at some small minor part s necessary to take down the entire motor. Of course s practically impossible to build a motor in which ry part can be removed without disturbing some other t, but the nearer one can come to this ideal condition better. Cylinders should be removable without urbing the base or shaft, and all piping and water nections should be so arranged that they can be ly removed or disconnected without disturbing the of the motor. In this connection the fly-wheel is onsiderable importance, and in many motors this ery difficult to remove, although, in order to reach gears or pump eccentric, it is necessary to remove it. eels that are fitted to a straight shaft and keyed in e often rust fast to the shaft and are almost as solid f a part of it. While it is absolutely necessary to e the fly-wheel tight, to avoid vibration and pounding, it should be fastened in such a way that it can be en off without special tools or machinery. Several kers use a tapered end to the shaft fitted in a tapered e in the fly-wheel. The wheel is forced on the taper a large nut and is prevented from slipping by a key g. 56). Such wheels are usually easy to remove, a still better plan is to use a bushing of bronze ween the shaft and the wheel, as this prevents the wheel from rusting to the steel shaft (Fig. 57).

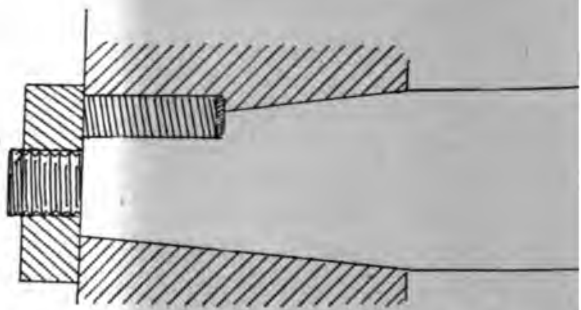


Fig. 56.—Tapered Fly-wheel Shaft, with Key

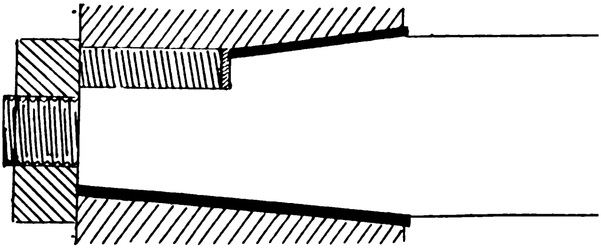


Fig. 57.—Tapered Fly-wheel Shaft Bushed

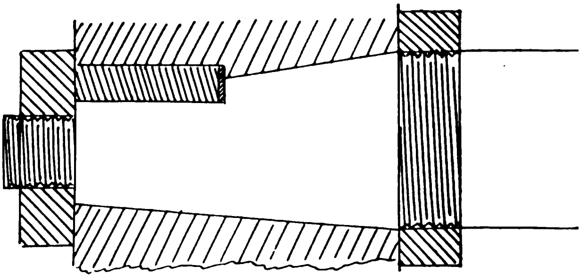


Fig. 58.—Tapered Fly-wheel Shaft with **Releasing N**

another method which renders the wheel easy to ve is illustrated in Fig. 58. This consists of a ed shaft with shoulder *A*, which is threaded and ded with a nut *B*. The wheel is forced up on the and shoulder as in the ordinary tapered shaft he nut *B* is then set up against it. When the wheel be taken off the forward lock-nut *C* is removed, y turning the rear nut *B* against the wheel the latter ily forced off the shaft. This idea is original with uthor and has been employed on several motors great success. Even with a straight shaft and key ar nut will force the wheel from the shaft unless badly corroded.

CHAPTER V

Motor Accessories—Vaporizers—Carburetors—Cooling Systems—Fans and Pumps—Circulating Devices—Lubrication—Gravity and Force-feed Oilers—Grease Cups—Oiling Systems.

All attachments and parts of a gasolene engine, not actually a part of the motor itself, may be classed under the general head of Accessories, for while these various devices may outnumber the parts of the motor and the latter may be incapable of operating without them, yet they are seldom manufactured by the motor manufacturers and often are of equal importance and of greater value than the bare engine. In fact a motor without accessories is no better than so much old metal, as far as use is concerned. Nevertheless, many owners or operators of gasolene motors who are very careful to purchase or use the best motor that money can buy are very careless or indifferent where the attachments or accessories are concerned. In reality most failures of gasolene motors to give satisfaction are due to faulty or poorly constructed or obsolete accessories. The best motor in the world will not operate properly with poor ignition or poor vaporizing devices, whereas a poor motor will often work fairly well if furnished high-class ignition and fuel-mixing apparatus. Every gasolene motor must be supplied with some sort of device for furnishing the explosive gas and for so combining the air and fuel as to the proper mixture or "gas" to give the greatest ble explosive force without waste of fuel.

ch devices are known as mixers, carburetors, or rizers, and they may be roughly divided into three ɔs: Vaporizers, Float-feed Carburetors, and Me- ically operated Mixers. Gasolene, benzine, kero- alcohol, or any other liquid fuel must be vaporized ansformed into an explosive gas by mixing with air

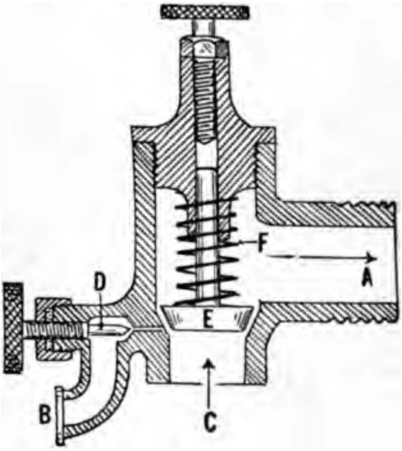


Fig. 59.—Vaporizer

'e it can be utilized as a fuel for internal-combustion ıes. The function of either mixers, carburetors, ıporizers is to create a mixture of gasolene or other vith the air in such proportions as to give the highest ency. Vaporizers as a rule are cheaper and simpler carburetors and are not nearly as satisfactory. A non form is illustrated in Fig. 59. In this cut *A* represents the inlet to motor; *B*, the gasolene supply pipe or inlet; *C*, the air intake; *D*, the needle valve; and *E*, the check valve. The gasolene flows through the opening of the needle valve *D* and the amount admitted to the motor is varied by screwing the valve up or down. While the check valve *E* is held on its seat by the spring *F*, the opening of the needle valve is closed and no gasolene flows through. As soon as the motor commences to operate the suction through the inlet *A* draws air through the inlet *C* and this suction raises the check valve from its seat, allowing a small jet of gasolene to run into the vaporizer. This gasolene is mixed with the air as it rushes through from *C* to *A* and passes into the motor in the form of a vapor or fine spray. By varying the adjustment of the needle valve *D* and the lift of the check valve *E*, the proportion of gasolene to air can be varied to suit the speed or condition of the motor. In theory this system is excellent, but in actual operation it often proves faulty.

The best form of fuel mixer is undoubtedly the float-feed carburetor. A number of makes of these carburetors are on the market and each has its own good points and advantages. The operation of all is very similar and if one is thoroughly understood the others are easily mastered. A form in common use and which invariably gives most satisfactory results is known as the "Schebler." This carburetor is made in several forms and types, varying in the arrangement of air and gasolene supply and regulating devices, but the simpler form known as "Model D" is as satisfactory for general use as any and is far easier to understand than the more complicated models. This carburetor is illustrated in Fig. 60, in which *R* represents the inlet to motor; *G*, the gasolene pipe inlet; *A–C*, the air intake; *D–E*, the needle valve; *O*, the automatic air valve; *F*, the float; and *H*, the float valve. The flow of gasolene fills the float chamber *B* until the float *F* rises upward and shuts off the supply by the float valve *H*. As long as the motor is inactive this level remains constant and no gasolene passes into the motor. As soon as the piston moves on the suction, or intake, stroke a current of air is drawn through *C* and across the opening of the needle valve towards the motor

MODEL "D"

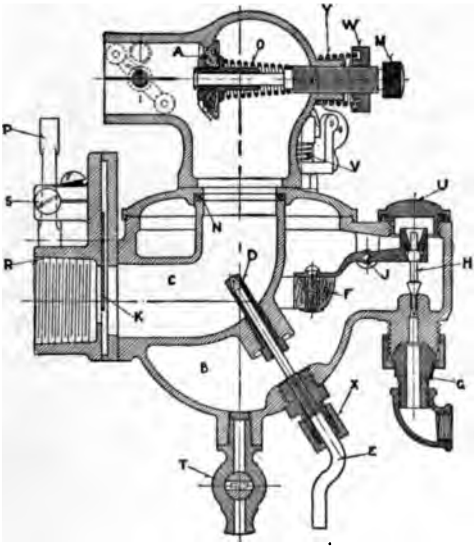


Fig. 60.—Schebler Carburetor

inlet *R*. This draught of air sucks a small quantity of gasolene from the opening of the needle valve and this, gathering upon the walls of the air passage, rapidly evaporates and is readily combined with the inrushing air and converted into an almost dry gas or vapor. The small amount of gasolene drawn from the full chamber is at once replaced by the automatic action of the float and float valve. The proportion of air to gasolene is easily and accurately regulated by means of the needle valve and air valve, *D* and *O*. It is usual to regulate the supply for the motor while running at medium speed and then by speeding up and slowing down so adjust the automatic air valve *O*, by means of the thumb nut *W*, that the best results are obtained at all speeds. The function of the check valve which is attached between carburetor and engine is merely to prevent the vapor in motor base from rushing back through the carburetor instead of upward through the by-pass to the firing chamber. It is therefore only necessary on two-port, two-cycle motors, for in the three-port type the piston itself acts as a check valve, while in four-cycle motors the mechanically, or spring, actuated intake valve prevents any backward pressure of the gases.

This carburetor, as well as those of other makes and most vaporizers, is also provided with a throttle valve *K*, operated by a lever *P*, and which shuts off all or a portion of the gas entering the chamber of the motor by closing the opening *R*. This lever may be so adjusted by the set-screw *S* that the throttle cannot be completely closed, but will serve to feed just the right unt of vapor to operate the motor at the slowest ible speed.

ıother excellent carburetor of the float-feed type is "Krice" illustrated in Fig. 61. In this carburetor the motor connection, *D* the cylindrical throttle; ıe annular gasolene openings; *F* the gasolene level

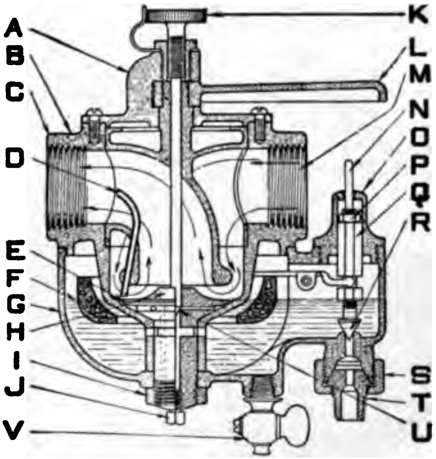


Fig. 61.—Krice Carburetor

float; *G* the gasolene bowl; *K* the needle-valve ıstment; *L* the throttle lever; *M* the air intake; he inlet valve operated by the float; *T* the gasolene nection; *U* the needle valve; and *V* the drain cock. advantages claimed for this carburetor are that the ılene, instead of being drawn from the needle-valve ning direct, is drawn through a narrow slit or open- nearly three inches in circumference and 1/100 of an ı wide and is vaporized within the chamber *H*, thus producing more rapid evaporation and drier gas. T throttle *D* is also novel, being semi-cylindrical in for and not only acts as a throttle, but also as an air adju ment for varying speeds of the motor.

Still another excellent type of float-feed carburet

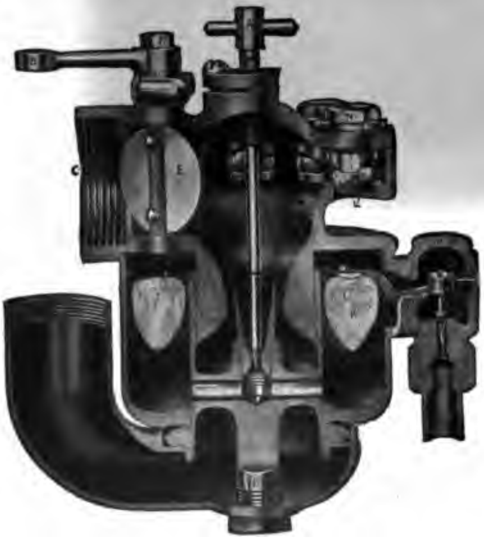


Fig. 62.—Kingston Carburetor

is the "Kingston" illustrated in Fig. 62. This c buretor acts on the same general principle as th already described, but has five supplemental air-sup inlets which are automatically opened and closed bronze balls *M*, which float within the retainers *N* high speeds, but close against their seats at slow spe thus doing away with the more uncertain spring acti of other automatic air-regulating devices. As a r the simpler and more positive the better in carburetor design, for a slight derangement in any part will result in variation of mixture and loss of power or stoppage of the motor.

A form of mechanically operated mixer is shown in Fig. 63, which represents the mixer used on the Cadillac

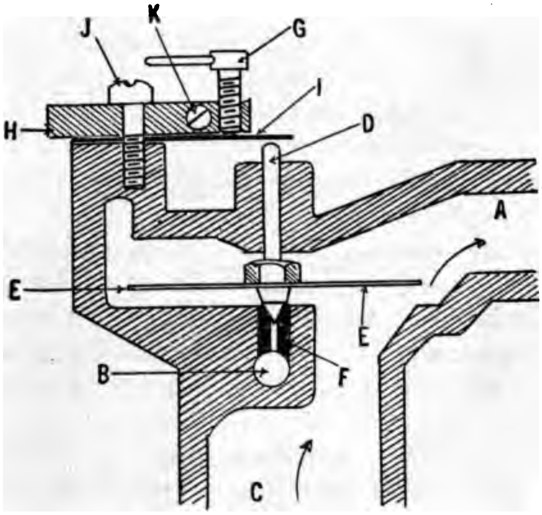


Fig. 63.—Mechanical Mixing Valve (Cadillac)

single-cylinder automobiles. In this cut, *A* represents the inlet to the motor; *B* the gasolene inlet; *C*, the air intake; *D*, the needle valve; *E*, the diaphragm; *F*, the valve seat; *G*, the adjusting screw; *H*, the mixer binder; *I*, the needle-valve spring; *J*, the binder screw; and *K*, the adjusting-screw binder. In operation the air, drawn inward by the suction stroke of the cylinder, causes the diaphragm *E* with the needle valve attached to lift from the valve seat and thus permit a small quantity of gasolene to escape and mix with the inrushing air. The screw *G* bears upon a spring *H* which presses upon the top of the needle-valve stem, and this spring and screw are adjustable by means of the binder *H* and screw *J* so that the spring exerts greater or less pressure upon the needle valve and thus allows it to raise higher or lower according to the requirements of more or less gasolene. When correctly adjusted this mixer gives excellent results, but the adjustments must vary with climatic variations and the conical head of the needle valve and its seat become rapidly worn and often permit too much gasolene to enter the chamber.

The carburetor of a motor is its most delicate piece of mechanism and has been aptly called the "Heart of the Gas Engine." It should never be tampered with until everything else has been looked over in case of trouble, for it is often the work of several hours to readjust a carburetor correctly. It is a very common fault of many operators to continually fool with the carburetor or even to use it to turn off the supply of gasolene by screwing the needle valve onto its seat. This is a practice that cannot be too strongly condemned. Turning the needle valve against its seat injures both valve and seat and it is practically impossible to adjust it once it becomes rough, burred, or bent. A regular cut-off valve or cock should be placed in the pipe line outside the carburetor, and this should always be used for shutting off the fuel supply when the motor is not in use. A great deal of trouble with carburetors is caused by water, or particles of dirt, getting in the gasolene and finding ts way into the needle valve. A gasolene-strainer hould be placed between the fuel tank and carburetor, ut even this will not always prevent foreign matter om working into the valve. Practically all float-feed rburetors have a drain cock at the bottom of the chamer, and this should be frequently opened after the motor as stood idle for some time and the gasolene allowed run off. If the gasolene thus drained is caught in a ass bottle or similar vessel you will be surprised to find ow much water or dirt frequently drains off. On ultiple-cylinder motors it is often customary to use a ngle carburetor with the intake pipe or manifold ttached to the several cylinders. This system often orks to perfection, but in other cases a separate caruretor attached to each cylinder proves far more satisctory. Frequently on two-cycle, two-port motors parent carburetor trouble is due to the check-valve ring being either too weak or too stiff. It usually ys to have several springs of varying strengths on nd and by experimenting with these excellent results y often be obtained when it is impossible to get satistory operation through carburetor adjustments alone.

A very important part of the motor is the cooling stem. In the case of air-cooled motors a simple fan iving the cool air across the motor is all that is required, d this is so simple and so easily watched that any ndency to overheat can be easily attended to. In the se of water-cooled motors the system is far more mplicated, and overheating may be caused by some ortion of the cooling system failing to operate where is very difficult to locate it. A very simple system of

water-cooling used in many stationary motors, a
some vehicle motors, depends upon the well-k
fact that hot water rises, and by placing a hopp
radiator, at an elevation slightly higher than the

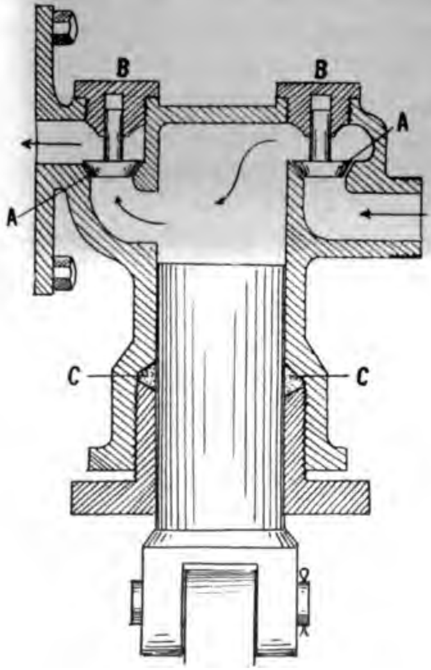


Fig. 64.—Plunger Pump

and connecting it to the water jacket the water
tinually flows through the motor about the cyl
This system does not prove very satisfactory with
cycle motors, as in this type of engine the explos
every revolution tends to heat the cylinder wal

faster than in the four-cycle motors where an explosion only occurs at every other revolution, thus allowing the motor to cool off appreciably between the explosions. Usually a pump of some sort is used to force the water through the jacket and around the cylinders. This pump may be either of the plunger type (Fig. 64), of the gear type, or of the true rotary type. The plunger type of pump is very satisfactory where clear water is used, but in marine use it frequently becomes clogged by bits of seaweed, shells, gravel, or other matter becoming wedged between the check valves (Fig. 64, *A*, *A*) and their seats. This is readily removed by unscrewing the check-valve caps (Fig. 64, *B*, *B*).

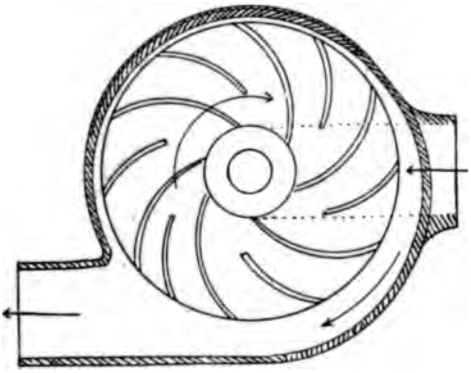


Fig. 65.—Rotary Pump

In addition to this trouble the plunger pump is usually noisy and requires packing around the plunger (Fig. 64, *C*, *C*) in order to keep the pump from sucking air. Even when the plunger packing is as tight as it

otary pump is a very
be driven by belt, cog-wheel, s
by similar mechanical means; it
operating noiselessly and, moreo

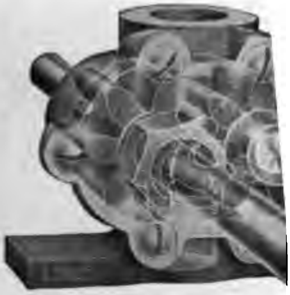


Fig. 66.—"Lobee" Gear

some distance from the engine o
venient. A common form of this
Fig. 65, but the shape of the pad
varies with different

always flow in the direction of revolution as indicated by the arrows in Fig. 67, *A*, *B*. For this reason a check valve should be placed between the engine and pump when a motor is frequently reversed, for otherwise air may be drawn into the intake pipe and an air-lock formed which will prevent the pump from working satisfactorily until the air is forced out and the pump primed, by pouring or forcing water through it and the pipes. Marine engines should always be provided with two check valves on the water pipe, one between pump and intake in boat and the other between the pump and water jacket (Fig. 38, *CV*). These prevent the water from flowing back from the cylinder through the pump, thus causing air in the pipes, and also prevent the boat

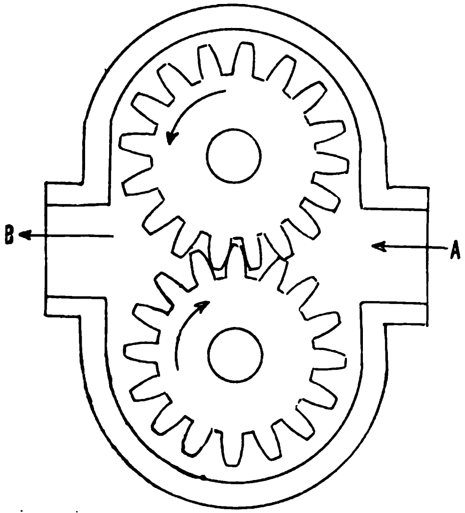


Fig. 67.—Flow of Water in Gear Pump

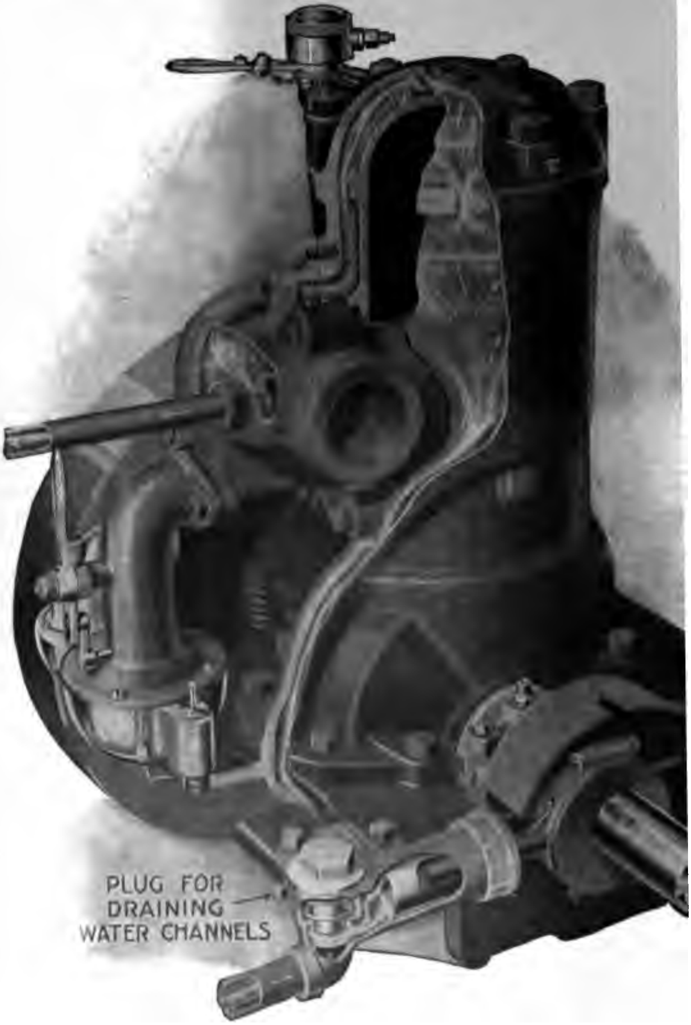


Fig. 68.—"Ferro" Water Circulation System

from flooding if the pump, engine, or pipes are below water line. With a rotary pump it is a good plan to have a cock or valve at the pump, or close to it, as in this way the pump can be primed, or oiled, through the cock without trouble. Both plunger and rotary or gear pumps should also be provided with a drain cock at the lowest point, from which all water may be drawn in cold weather to prevent freezing, and there should be a test cock between pump and engine so that by merely opening this the operator may readily ascertain if the pump is operating properly.

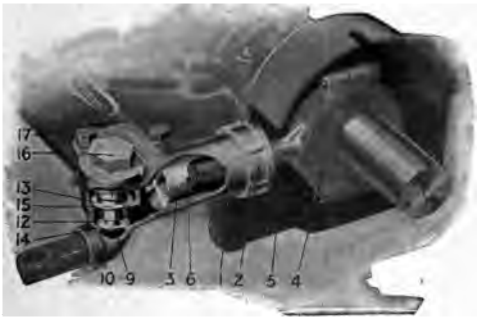


Fig. 68 *a*.—"Ferro" Water Circulating System

The water-cooling system in the Ferro engines (illustrated in Fig. 68) is unique and is well worthy of consideration. In these motors there is no exposed piping or connections as the water from the intake is pumped directly into the water jacket by means of a plunger pump directly connected to the shaft. In the illustrations the system of circulation as well as the simplicity of the pump are plainly shown. After leaving the pump the water is forced through a channel in the crank case and hence up to the jacket. Entering the water jacket the water divides and passes up on both sides of the exhaust port and then up and around the cylinder to the cylinder head, from which it passes into the exhaust manifold. It can then be piped either directly to a tank, to the outboard connection, or can be led into the exhaust pipe. At the lowest point in the water channel in the crank case there is a drain cock from which all water may be drained from the cylinder.

Almost as important as the vaporizing system is the lubrication equipment, for if allowed to run dry, or with too little oil, a gasolene motor will at once heat up and will soon be ruined beyond repair. If fed too much oil, carbon will accumulate in the cylinder, on the piston and valves, and will even choke up the muffler and exhaust, besides causing a disagreeable odor and excess of bluish smoke. Lubricators or oilers may be divided into three groups: gravity oilers, force-feed oilers, and grease cups. Gravity oilers consist of a tank or other receptacle to hold the oil, with pipes running to the various points of the motor requiring lubrication. They operate by the oil dripping through from the reservoir by gravity, and in order to aid in their operation a small ball check is usually placed at the top of the oil pipes. This class of oilers is in general use and they may consist of either a large tank from which numerous pipes lead, or may be merely independent oil cups. Several makers now have glass-bodied oil cups with several feeds, as illustrated in Fig. 69. For small or single-cylinder motors these oilers answer all requirements, but they require frequent refilling and the best of them are apt to leak oil and become greasy and dirty.

Force-feed oilers are very different in principle and construction; they consist of a tank or receptacle for the oil, within which is a compact oil pump operated by a lever, pulley-wheel, or gears connected to the engine, and this pump forces the oil through the pipes to the proper points. As the pump will force the oil against high pressure there is no danger of the pipes becoming clogged or the oil failing to reach the bearing surfaces. On some portion of the oiler there are small tubes, enclosed by glass, through which the oil is forced in drops in exactly the quantity that it is fed to the engine. This acts as a sight feed, and by means of plungers, or screw adjustments, the flow of oil to any or all pipes may be regulated to feed the proper amount. On large-size, multiple-cylinder, vehicle motors or any motor that operates for some time without continual observation, the force-feed system is a necessity, and although the first cost is more than for the gravity oilers the results are fully worth the additional outlay. An excellent type of this class of oilers is manufactured by the Detroit Lubricator Co. (Fig. 70), while those of the Osgood

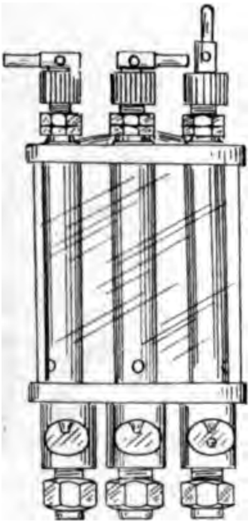


Fig. 69.—Multiple-feed Oiler

Lubricator Co. are illustrated in Fig. 71. Grease cups are used on bearings, shafts, and smiliar places, and consist of a cup which is filled with grease that can be forced onto the bearings by means of a plug, or plunger, screwed into the cup (Fig. 75). For marine and stationary work these grease cups answer very well, but if the motor is provided with a force-feed lubricator or a tank gravity-feed oiler it is better to oil the bearings by the regular lubricator pipes. The principal points for lubrication are the piston, piston-pin, connecting-rod bearing, main bearings, and, in four-cycle motors, the gears, cams, and push-rods.

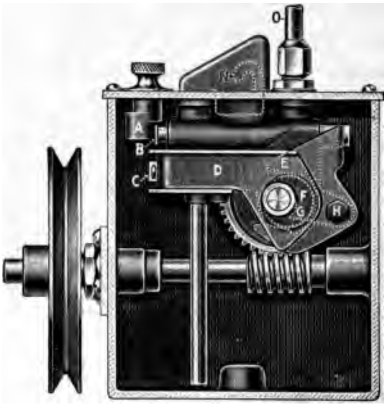
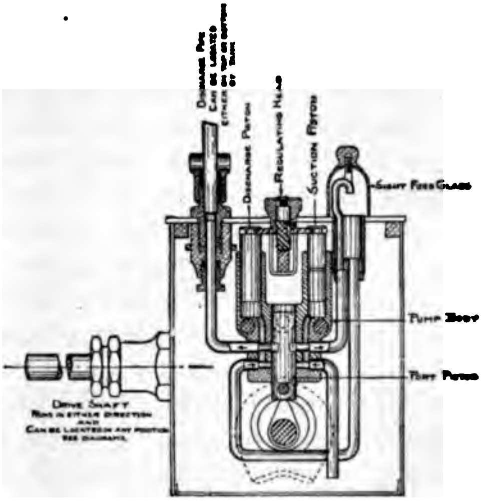


Fig. 70.—"Detroit" Force-feed Lubricator

The proper amount of oil to be fed depends largely upon the size and speed of the engine and its age and care. A new motor will require more oil than one which has been operated for some time, while an engine that has become badly worn, and loses compression, may often



Sectional View

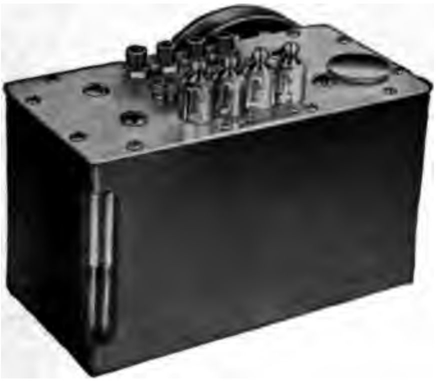


Fig. 71.—"Osgood" Force-feed Lubricator

be made to operate far better by feeding an excess
which serves to fill the leaks around piston rings
bearings and thus hold compression. Usually fro
to fifteen drops per minute is sufficient for a well-care
motor. Another method of lubrication that has
advantages consists of oiling the motor through
gasolene. To accomplish this, oil should be add
the gasolene in the proportion of one pint of oil t
to eight gallons of gasolene. The oil and gasolene
be thoroughly mixed and this may be accompl
either by stirring them together before placing i
tank or by pouring both together through a f
with a strainer. Another method is to mix the oil
a small quantity—about a gallon—of the gasolen
then add this to that in the tank. The oil
mixed is held in suspension in the gasolene in m
globules, and passes with the gasolene through
carburetor. Within the motor the gasolene is vapo
while the oil is deposited over all parts of the int
of the motor, thus lubricating it very thoroughly.
method gives excellent results but has numerous d
vantages. If one has a private gasolene supply wher
oil may be properly mixed in known proportions
is little trouble, but if you purchase oil or gasolene
there, and everywhere—as is necessary when
cruise with a boat or on a long automobile tri
is next to impossible to get the proper proportions
time; either too much or too little oil is sure to
under such conditions, and in addition it is conside
trouble to stop and mix the oil and gasolene
time the tank is refilled. Moreover, the oil pa

through the carburetor has a tendency to keep the carburetor oily and accumulate dirt, while oftentimes the oil becomes gummy and hard from cold weather, or from the cold generated by evaporation on the carburetor, and the latter then becomes clogged and fails to operate properly. In four-cycle engines the oil often accumulates on the valve stems and causes them to stick, or is forced into the exhaust pipe and muffler, causing clogging and soot.

The most difficult parts of a motor to lubricate successfully are the piston-pin and crank-shaft bearing of the connecting rod, and this is accomplished in various ways. A common and good method is to have a hole bored through the piston-pin and another through the connecting rod connecting with the former. The oil, fed into the cylinder, lubricates the piston and also enters the hole in the piston-pin and, after lubricating the bearing at the head of connecting rod, finds its way down to the crank shaft. This method is excellent on small to medium-sized engines and is well shown in Figs. 38, *M*; 43 and 44, *O*; and in Fig. 74.

To lubricate the crank-shaft bearings still more effectively a splash system is used in many motors in which a quantity of oil is kept in the bottom of the crank case and into which the connecting-rod cap and crank shaft dips at each revolution, thus splashing the oil about and lubricating the various internal parts. Practically all two-cycle motors lubricate more or less on this principle, for there is always an excess of oil accumulating in the base into which the crank dips. To more evenly distribute the oil in the base a system of oil rings is often used by the best makers of gasolene motors and has been adopted on the majority of good motors. This method consists of rings attached to the crank shaft and to which oil is fed through the base or otherwise. The centrifugal action of the oil rings, which are slightly eccentric, serves to keep up a steady and uniform feed of oil to the various parts of the crank and shaft bearings. This ring system is far superior to the splash method, and is illustrated in Figs. 72 and 73, which show the ring used by the Buffalo Motor Co. and the crank shaft with rings assembled. This company was the first to introduce these oil rings and they have since been adopted by many manufacturers and are used with various modifications almost universally.

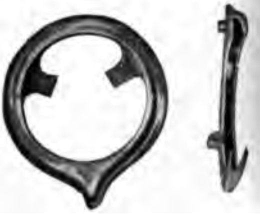


Fig. 72.—"Buffalo" Oiling Rings

A unique and very compact as well as highly satisfactory system of oiling is used in the well-known Ferro motors. This is well shown in the sectional view illustrated (Fig. 76), and consists of an oil tank in the base of motor and cast integral with it. This is filled by means of a filler tube (6) which rises from the base. A short tube fitted with a check valve connects the crank case with the tank and from the latter another tube (5) leads upward to the sight-feed distributor at top of cylinder. From the distributor various feed pipes lead to the points requiring oil. In operation the pressure in the crank case causes enough air to pass through the check valve into the oil reservoir to force the

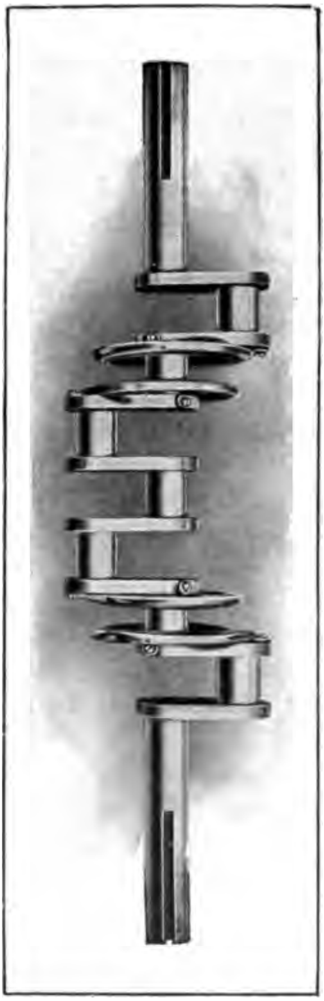


Fig. 73.—"Buffalo" Oiling Rings on Shaft

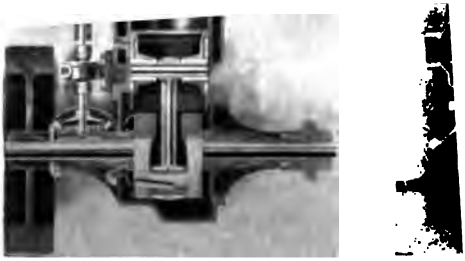
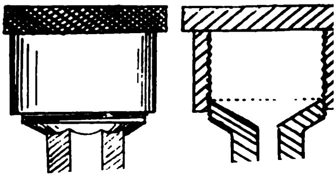


Fig. 74.—"Gray" Lubricating Sys

to the various points requiring lubricatic
adjusting the needle valves on the distrib
ing the tank full of oil, this device req



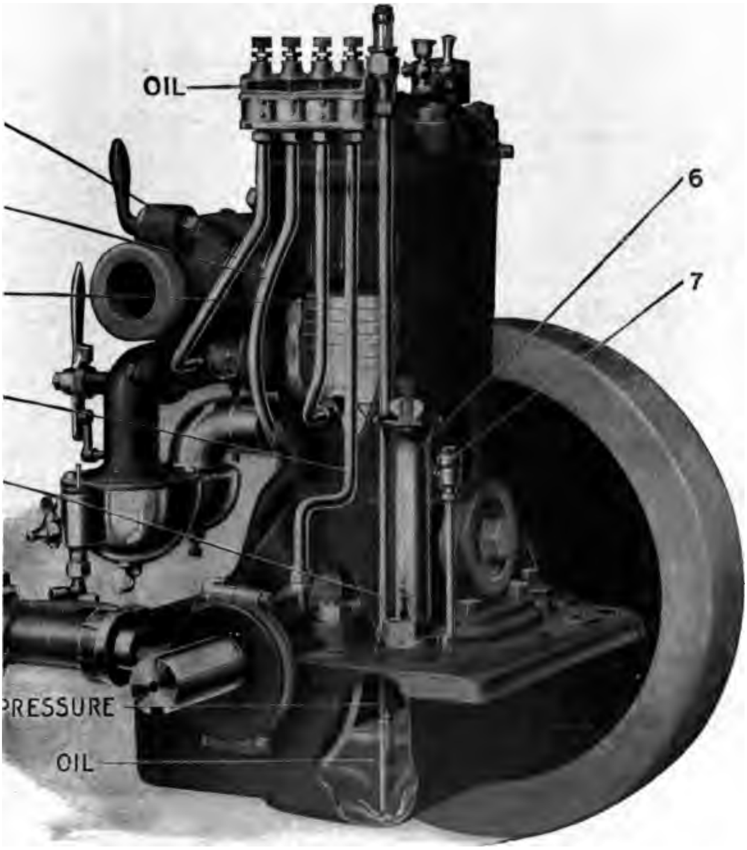


Fig. 76.—"Ferro" Lubricating System

CHAPTER VI

IGNITION.—PRINCIPLES OF ELECTRICAL IGNITION.—DYNAMOS AND MAGNETOS.—HIGH- AND LOW-TENSION MAGNETOS.—THE WICO IGNITER.—SPARK COILS.—SPARK PLUGS.—VIBRATOR.—TIMERS.—DELCO AND PERFEX SYSTEM.—IGNITERS.—OPERATION.—COMPARISON OF MAKE-AND-BREAK AND JUMP SPARK.—ALTERING MAKE-AND-BREAK TO JUMP SPARK.

EVERY internal combustion engine must be provided with some method of igniting the charge of compressed gas in the cylinder, and while in the past this was accomplished in several ways, at present practically all gasolene engines use an electric spark for the purpose. Electric ignition in general use may be divided into two classes, Jump-spark and Make-and-break-spark ignition systems, but before discussing these two methods in detail a short explanation of the general principles of electricity as used for ignition purposes may be of interest. Electrical currents are said to "flow" through certain conductors, such as metallic wires, but the exact actions of these currents are not known. It is generally conceded, however, that the current does not pass through the body of the metal as much as it follows the surface. A clearer idea of electrical action may be obtained by comparing the current with the flow of liquid through a pipe. A liquid in a pipe is said to be under a certain pressure which causes it to move, the pressure being due to a difference in level of the source and outlet, or caused by some mechanical means as a pump. In the same way an electrical current has pressure or *voltage* caused y a difference in what is known as a ***potential*** (see lossary) between the source and the outlet; thus we ave:

> *Volts* = the unit of pressure dependent upon the difference in *Potential*, equivalent to *lbs. per sq. inch* = unit of pressure dependent upon difference in level.

The amount of water or liquid passing a given point uring a certain time is known as the rate of flow in allons per minute, etc. So a current of electricity has similar rate of flow, which is measured by a unit known s an *Ampere*, which represents quantity just as in a ater pipe the quantity is reckoned in gallons. The uantity of water is dependent upon the pressure used o force the water through the pipe and upon the resistnce or friction of the pipe. In the same way the numer of amperes in an electrical current depends upon e pressure or voltage and upon the resistance to the assage of the current through the wires, or other nductors. Thus we have:

> *Ampere* = unit of rate of flow, dependent upon voltage and resistance; equivalent to *gallons per minute* = unit of rate of flow, dependent upon pressure per sq. inch and frictional resistance.

he resistance to the flow of an electrical current is easured by units called *Ohms*, and is dependent upon e diameter, material, length, and temperature of the ires, exactly as the flow of water is resisted by friction ependent upon the size, shape, and length of a pipe. herefore we may compare:

> *Ohm* = unit of resistance dependent upon diameter, material, and length of wire; with *coefficient of friction* = unit of frictional resistance dependent upon diameter, shape, and length of pipe.

The two general sources of electricity for ignitio wet or dry cells and magnetos or dynamos. A st battery does *not* generate electricity but merely that generated by a dynamo or other apparatus. passing the electrical current through a contri known as a "spark coil" a certain change takes in the electrical current and the voltage is incr If the coil consists of a soft iron core with numerou of wire around it it is known as a *Primary Coil*, the kind used in the make-and-break system of ign If, however, the coil is composed of two different of wire with the outer coil finer than the under an connected with it, it is known as a *Secondary Coil* as is used in the jump-spark system.

Dynamos and magnetos are mechanical devices to produce electricity, and a simple form of one of is represented diagrammatically in Fig. 77. The *A* and *B* are electro-magnets, or, in other word pieces of iron magnetized by means of a small c known as a *shunt S*, made to pass around them as s This shunt current is really a small part of the c produced by the dynamo itself. The ends of thes pieces of iron are known as *poles* and between the space known as the *magnetic field*. In this area a or *armature*, *C*, is rotated, upon which wires are w so that the windings are continually passing th the lines of force between the poles and thus cu of electricity are generated in the wires. As the ro of the armature causes currents in the wires whic in opposite directions, these currents are gather they will flow in one direction through the outside he current is to be used, and to accomplish this : small pieces of carbon or other substance as *brushes*, *D*, are used which rub on small ts of copper known as a *commutator*, *E*, at-

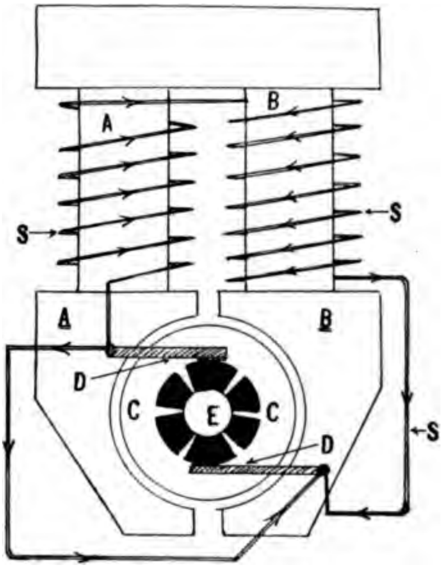


Fig. 77.—Diagram of Dynamo

to the end of the armature and to which are d the ends of the wires used in winding the re. The brushes are so arranged that they touch per pieces connected with the proper wires so direct current will flow through the outside

ig. 78 is a diagrammatic section of a magneto. and *B are the* magnets, but in this case they are permanent, or true, magnets and no shunt current is required; it is mainly in this detail that dynamos differ from magnetos. An electrical field exists between the poles or ends of these permanent magnets, and a

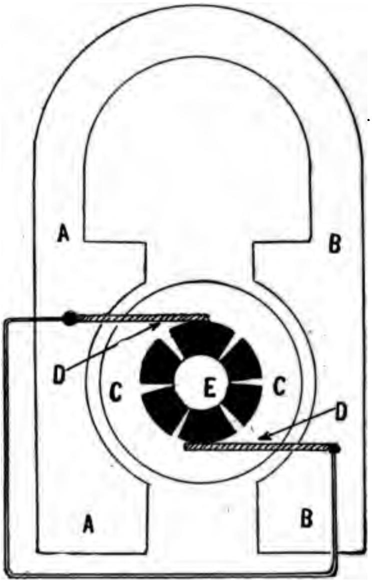


Fig. 78.—Diagram of Magneto

revolving armature *C* with its windings cuts through the lines of force, producing currents in the wires exactly as in the dynamo. Brushes *D* and a commutator *E* are again used in this case to gather the flow of current in one direction. The strength of current generated by the above machines is dependent upon the size of wire, the strength of the magnetic field, the number of turns of ıd the speed at which the armature is rotated. reason the shunt current of the dynamo increases as the speed of the machine increases, thereby ng the magnetism of the electro-magnets and d so that the strength of current will increase pidly in this type with the speed at which it is d than it will in a magneto with permanent s. To obviate this difficulty with the dynamo nor is supplied which regulates the speed of the re regardless of the speed of the engine to which chanism is attached. This governor is essential magneto or dynamo is to be used for ignition to prevent burning out the wires at high speed produce a good spark at low engine speed. As of current either a dynamo or magneto may be actly as if it were a storage or dry battery, or be attached to a switchboard and used to accu- electricity in a storage cell which can then be for ignition and lighting.

ıetos are divided into two general classes, high- and low-tension. The low-tension magneto of magnets as usual, but with a primary winding s in primary coils, and the current is broken at ant of its greatest intensity. Other low-tension os are fitted with timing devices by which the can be broken and a spark produced when thus allowing the spark to be retarded or ed and thus regulating the time when ignition charge in the engine takes place.

-tension magnetos have an armature provided wo windings like the jump-spark coils. These machines are fitted with a mechanical breaker which produces an induced effect on the secondary winding and therefore no spark coil is required. The Bosch, Simms, and various other magnetos are of this type. Another high-tension system consists in using a sort of low-tension magneto in which the current is passed through an induction coil fitted with a mechanical breaker. The Splitdorf, Holley, and Eiseman magnetos are of this type, while the Remy magneto has a stationary winding with two revolving inductors, thus eliminating revolving wires, brushes, and moving contacts. The great majority of magnetos in use, however, are of the low-tension type, and these possess the great advantage that their current can be passed through the regular spark coil and thus be switched off or on from the battery circuit at will. Moreover, these machines may be used with advantage for lighting purposes. The Eureka magneto manufactured by the Henricks Novelty Co. is of this type, and this wonderful little machine will ignite the motor charge and operate a total of 36 candle-power electric lights at the same time. This firm also manufactures a number of other magnetos, among them the "Comet," which is probably the smallest and most compact magneto made that is really practical. Many magnetos are inaccessible and are so complicated in construction that if out of order an electrical expert must be called on to adjust them. In the Comet the parts are very few and any one can take down, adjust, and repair one of these machines. The illustration (Fig. 79) shows the few parts and simple construction, while the brush holders can be removed without wrench or screw-driver, thus permitting examination or cleaning at any time.

A unique variety of magneto which has recently been perfected is the "Wico Igniter" made by the Witherbee Ignition Co. In this machine there is no rotary motion, the electrical current being generated by reciprocating,

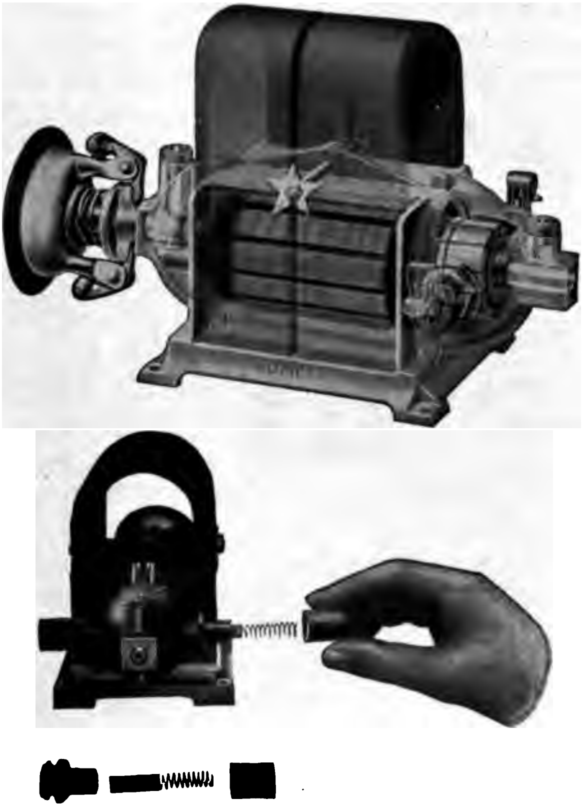


Fig. 79.—Parts of "Comet" Magneto showing Accessibility

or sliding, motion only. This remarkable machine is illustrated in Fig. 80. The magnets consist of tungsten steel permanently magnetized and fastened to cast-iron pole pieces which carry the magnetic lines of force from the poles to the soft iron cores. The pole pieces are fastened to the base casting and support the magnets' cores and coils. The cores fit into slots in the pole pieces and are built up of sheets of soft iron, and each core extends from just beneath the upper armature down through a pole piece and coil to just above the bottom armature. The armatures consist of sheets of soft iron mounted on a spool-shaped piece which in turn is loosely fitted onto the squared end of the armature bar. This armature bar is

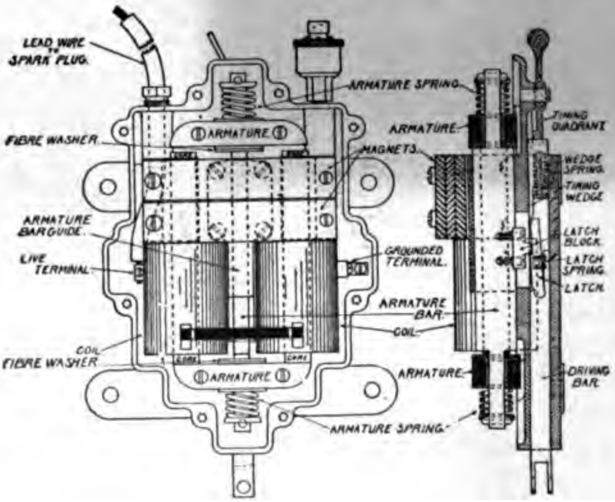


Fig. 80.—"Wico" Igniter

ce of steel, its central cross-section being flat while nds carry the armatures and are square. This s shoulders which bear against the armatures igh the medium of fibre washers, the shoulders ng to carry the armatures in and out of contact the cores when in operation. The armature itself ely supported by a box-shaped guide which is ned to the case. On the outer ends of the armature re spiral springs held in place by cup-shaped washers pins, making a self-locking fastening similar to -spring fastenings. These springs bear against the tures and force them against the shoulders of the ture bars. The coils each have a simple, high-on winding and are connected by a metal strip, making a continuous winding. In the single-der machine one end of the winding is grounded e case of the igniter while the other end runs to the plug of the motor. In two-cylinder machines ound connection is used, but both ends of the winding are connected to the plugs of the motor. In the of the case there is a square slot in which slides quare driving bar. This bar receives its motion the engine and at its upper end is provided with a ed latch of hardened steel. The latch is held in ist the latch block by a spring which fits into a s between the latch and the driving bar. Above the is a hardened steel timing wedge which is held rd against the timing quadrant by a spiral spring. timing quadrant is pivoted on the back of the case is moved by a small handle projecting above the

As the driving bar, connected with the engine, is moved upward carrying the latch with it, the shoulder on the side of the latch snaps under the square head of the latch block. As the motion reverses, the latch carries the latch block and armature bar upward. The lower armature being in contact with the stationary cores cannot rise with the bar, but the lower spring is compressed between the retaining washer and the armature while the bar rises and carries with it the upper armature which bears against the upper shoulders on the bar. As the driving bar continues its upward motion the bevelled upper end of the latch meets the lower end of the timing wedge, and as the wedge is stationary a further movement of the latch causes it to be pushed aside until its shoulder clears the latch block and releases it. As the lower armature spring is at this time exerting a pressure between the armature bar and the cores through the lower armature, the instant the latch is released the armature bar is pulled quickly downward carrying the upper armature with it. Just before the motion of the upper armature is stopped by hitting the cores, the lower shoulders on the armature bar come in contact with the lower armature and its momentum carries the lower armature away from the cores agains the pressure of the upper spring which acts as a buffer

The electrical action which ensues by this operation is as follows. With the parts in position as shown the magnetic lines of force starting from one pole of th magnets flow through the adjacent pole piece to th core, downward through the portion of the core covered by the coil to the lower armature, across to the othe core, and up to the other pole piece and other pole of the magnets, thus completing the magnetic circuit. The magnetic lines cannot travel upward and through the upper armature because it is separated from the cores by air gaps and the lower path offers less resistance. The portion of the cores covered by the coils is therefore magnetized, the same as in the core of a jump-spark coil. When the armature bar released from the latch is at the end of its downward stroke, the armatures occupy the opposite positions with relation to the cores —that is, the upper one is in contact while the lower one is separated. The magnetic circuit through the lower part of the cores is thus broken while the top forms a bridge for the magnetic lines across the tops of the cores. The combined action of the two armatures causes a very sudden demagnetization of the cores covered by the coils, which thus induces a wave of current in the coils, as is done in an ordinary induction coil when its core is demagnetized by breaking the primary circuit. In this igniter the permanent magnets replace the battery and primary winding, while the armatures replace the vibrator and timer in interrupting the magnetic flow through the cores. The timing of the spark is accomplished by releasing the armature bar earlier or later in the stroke. This is done by shifting the position of the timing quadrant which in turn varies the position of the wedge so that it releases the latch earlier or later. The timing quadrant is provided with several notches into one of which the top of the wedge fits, thus holding the quadrant in the desired position. At one end of the quadrant there is a notch considerably deeper than the others. This notch is so deep that when the wedge rests therein the latch is not tripped, and consequently the armature bar is not released and no spark is produced. In this position the quadrant acts as a switch and by mechanical means shuts off the current.

The advantages of this new form of igniter over rotating magnetos are numerous. It produces a hot spark at very high voltage for starting the engine, as the spark strength is entirely independent of the speed at which the engine is operated, and also because the voltage is strongest with the spark in its retarded or starting position. It is simple, strong, very compact, and dust-, oil-, and water-proof; moreover, it does away with all outside appliances and accessories such as switches, batteries, coils, wires, etc., the only wire exposed in the whole system being the short secondary wire leading from the igniter to the motor spark plug.

In using a jump-spark coil some method must be provided for interrupting or breaking the current in order to produce a spark in the induced current of the secondary winding. This is ordinarily accomplished by the use of what is known as a *Vibrator*. Fig. 81 represents a diagram of a jump-spark coil, and in this figure *A* is the core; *B*, the primary winding; *C*, the vibrator; *D*, the vibrator spring; *E*, the contact points; *F*, the adjusting screw; *G*, the condenser; *H*, the timer; and *I*, the secondary winding. As the core *A* is magnetized by the current passing around it in the primary winding *B*, the iron will, of course, be alternately magnetized and demagnetized as this current is made or interrupted. This intermittent magnetizing of the core is brought about by means of a timer, a mechanism on the engine which alternately connects and separates the points between which the primary current flows. This alternating magnetization and demagnetization of the core is used to operate the piece *C*, at the end of the spring *D*, in such a way that when the spring in its normal position is touching *E*, the current from the magneto or battery flows through the wire as shown by the arrows, thus magnetizing the core, but the instant the core becomes a magnet the piece *C* is drawn against its end, thus separating the spring *D* from the point *E* and breaking the primary circuit, causing the core to lose its magnetism and therefore allowing the piece *C* to spring back against *E*, again making the circuit, and thus operating over and over again as long as current is supplied to the primary winding. Non-vibrating coils

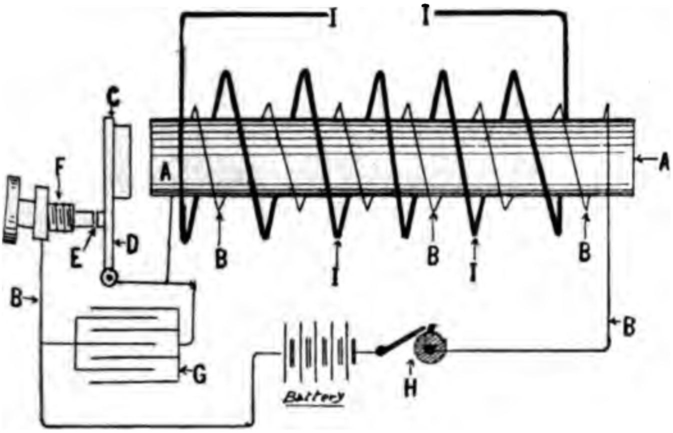
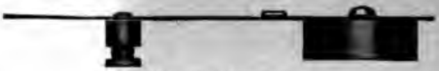
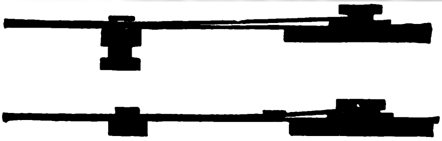


Fig. 81.—Diagram of Jump-spark Coil

are used on many engines, but in these coils only a single spark is produced each time the timer on the engine makes and breaks the primary circuit; and hence there is less likelihood of getting a powerful, hot spark than where the vibrating coil is used which produces a series of sparks at each contact of the timer points. The advantage of the non-vibrating coil lies in the fact that the vibrator, contact points, and adjustments are done away with, but as this type of coil does not "buzz" it is far more difficult to locate the trouble than with a vibrating coil in case of failure to "spark" properly.



Hammer Vibrator



Ribbon Vibrators

Fig. 82.—Types of Vibrators

An important part of the coil to consider is the vibrator itself, and upon the proper adjustment and construction of this depends in great measure the efficiency of the spark. Vibrators are made in various styles known as Hammer vibrators, Ribbon vibrators, Feather vibrators, etc. (Fig. 82), and the particular kind and make best suited to a particular motor can only be determined by experiment. As a rule slow-speed engines do best with a hammer vibrator, medium-speed motors with a ribbon tor, and high-speed motors with feather vibrators. od coil, when properly adjusted, should consume : ¼ to ½ ampere for each cylinder. By adjusting oints nearer together or farther apart by means of djusting screw *F* (Fig. 81), the amount of current ımed may be increased or decreased and the spark weaker or stronger. If the points are too close urrent consumed will be greatly increased without ısing the operation of the engine and with injury e coil. The aim should be to use just as little nt as possible and obtain a good spark and proper on. The best way to accomplish this is to test ow of current with an ammeter placed between the ry connection and the coil, and then adjust the ıntil it consumes the minimum current without ng explosions of the motor. If this method is not ıble it is a good plan to gradually loosen the adjust- :rew with motor running until the engine commences ss explosions. As soon as this occurs turn the screw very slowly until the engine runs regularly, and it in this position. When the coil is once properly ıted it should never be changed unless the motor s explosions or loses power and the trouble is ed in the adjustment of the coil.

e sparking points on a coil will frequently burn :ar down until they are pitted, are uneven, or stick her and fail to vibrate. This may be remedied ırefully smoothing them off with a fine flat file, ı better plan is to occasionally change the wires the batteries so that the current flows in the opposite tion and thus depolarizes the contact points. If your wires have been connected so that the carbon of the battery led to the coil and the zinc to the ground, shift them so that the zinc leads to the coil and carbon to the ground. An important part of all vibrator coils is the condenser (Fig. 81, *G*). This consists of layers of tin-foil separated by mica or paraffined paper. The sheets of foil are connected together alternately and these connections are then brought across the vibrator of the coil through proper wires. The condenser is usually placed in the bottom of the coil box, out of sight, and as the wires and connections are all inside there is no external evidence of the condenser and many users of coils are entirely ignorant of its existence. The function of the condenser is to reduce the spark at the primary break (at the vibrator points) which without it would be larger than that produced at the secondary terminals of the spark plug. This result is accomplished by the capacity of the condenser being just great enough to neutralize the self-inductance of the primary current by temporarily absorbing the impulse in the primary current at the moment it is broken by the vibrator. Almost instantly however, there is a reverse action and the stored energy in the condenser flows back with extreme rapidity and adds its quota to produce a larger secondary spark. In the Orswell and Perfex systems of ignition the coil is located in a casing attached to the spark plug, while the vibrator and condenser are in a separate case or box near the batteries. This obviates long secondary wires where short-circuiting is most likely to occur, and produces a hotter and larger spark, owing to lack of resistance that will occur where long secondary wires are used. Similar results are obtained by the use of cylindrical water-proof coils with vibrator attached to the cylinder of engine near the plug, as used on the Gray motors, or by a form of coil attached to the plug itself, as used in the Solocoil and Caille Perfection systems. In either of these latter systems the coil does not differ materially from an ordinary vibrator coil, but the length of secondary wire is reduced to a minimum and as the switch is placed on the coil itself only two wires lead from the battery to the engine.

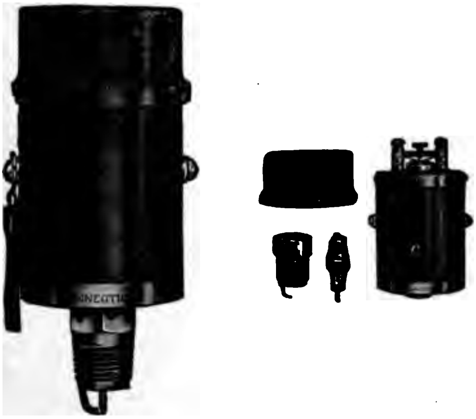


Fig. 83.—"Connecticut" Plug Coil

Another form of coil, manufactured by the Connecticut Telephone & Electric Co., which has recently been placed on the market, is designed to overcome all the usual troubles of the jump-spark system for marine work. This coil consists of a water-, heat-, and oil-proof casing attached directly to and covering the spark plug, thus entirely eliminating all secondary wiring and at the same time acting as a plug protector. Only two wires lead from the battery or magneto to the engine when this coil is used (Fig. 135) and no shock can be received when adjusting coil or plug. The case is covered with a tightly fitting metal cap that locks in place by bayonet locks, and the severest tests of this coil for injury by heat or water have failed to prevent its satisfactory action. The plug coil is illustrated in Fig. 83, and as will be seen the porcelains are readily removable and cost less than a common plug, while the position of the coil on the top of cylinder renders it very convenient for adjustment or examination. In fact this new coil has all the advantages and none of the disadvantages of the Perfex or Orswell systems. It is as secure from short-circuiting as these devices, and in addition does away with the separate vibrators and condensers with their attendant wiring. Several other manufacturers have recently placed similar coils on the market, but all operate on the same principle.

In the earlier forms of jump-spark ignition much trouble was encountered through short-circuiting, especially in the secondary current or spark plugs, and the use of the jump spark was largely confined to cabin boats and to stationary and vehicle use. With improved coils and magnetos, thoroughly insulated wire and timers, and highly developed spark plugs much of this difficulty has been overcome and little trouble is now encountered with short-circuiting, even in open boats. Usually the greatest trouble is in the spark plugs, and these simple and cheap accessories are often given far less attention than they deserve. There are a large number of makes of plugs on the market—some good, others better, and some very poor—and it will always pay to have the best and to keep several on hand for emergencies. The ordinary types of plugs are shown in Fig. 84, which illustrates the forms known as the "Petticoat" and "Conical" types, as well as the porcelains removed to show internal construction. These answer very well for stationary or vehicle use, but where used in an open boat or under severe conditions of any sort a specially constructed plug should be used that will resist short-circuiting to the highest degree. Probably the nearest to a trouble-proof plug yet produced is the Reliance. This plug in its various forms is illustrated in Fig. 85. The porcelains are also shown removed, and the sectional view shows the internal construction. These plugs are provided with a very small platinum point embedded

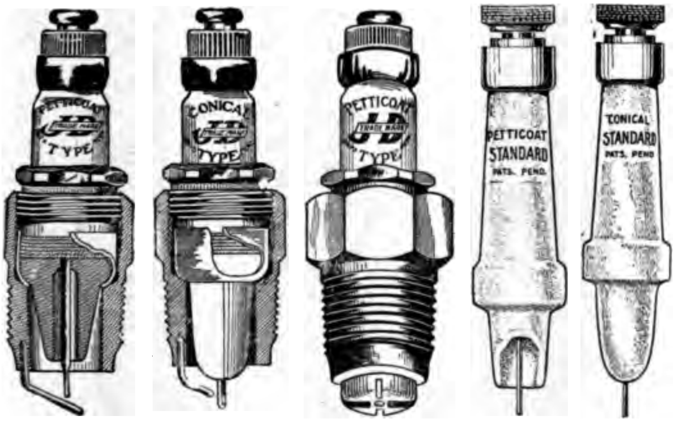


Fig. 84.—Types of Standard Plugs and Porcelains

in the porcelain and ground flush with it. Above this and connecting it with the terminal at the top of plug is a copper quill and spring which compensates for any difference in expansion and contraction between the porcelain and metal and also prevents breakage of the porcelain by tightening too much on the packing nut. The fine platinum point concentrates and intensifies the spark to such an extent that the heat and scouring action instantly destroys any short-circuiting material around it on the surface of the porcelain. So efficient is this action that a Reliance plug will actually spark when immersed in a glass of water.

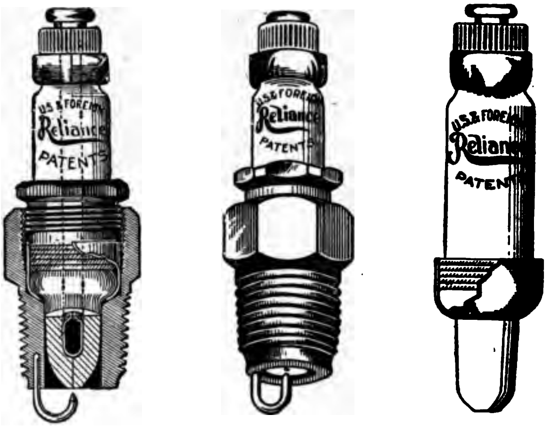


Fig. 85.—"Reliance" Plugs and Porcelain

Notwithstanding this high efficiency they will at times short-circuit when hot and suddenly drenched with spray or when thoroughly saturated with moisture after being exposed to rain or fog. By merely wiping off the outside of the porcelain and rubbing with oil or grease the trouble is readily overcome, however, and the spark plug will continue to operate as before. Probably no plug can be made that will not occasionally short-circuit under severe marine conditions, and the Reliance is certainly very near perfection. Many other excellent plugs are to be had and the choice lies mainly with the user; one person having far better results with one kind than another. The Wright, Spit-fire, Never-miss, Sta-rite, Sootless, Red-head, and many others are all good plugs and give highly satisfactory results Several makes are so constructed that they may be readily taken apart for examination or cleaning, and this is a most valuable feature where the plug is difficult to remove from the cylinder or is inaccessible. The Breech-block plug (Fig. 86) is constructed with the porcelain held in position by an interrupted screw which is turned by a lever and can be almost instantly opened and closed the same as the breech block of a modern cannon. The Rajah plugs illustrated in Fig. 87 are also readily taken apart and consist of but four pieces, all of which are interchangeable and easily removed or replaced. When using a high-tension magneto for ignition separate plugs must

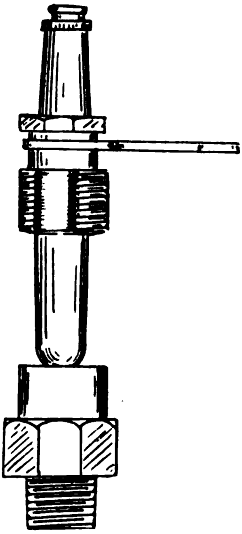


Fig. 86.—Breech-block Plug

be used for the battery and magneto, and this requires two plugs in the cylinder. Magneto plugs are especially constructed to withstand the high, hot current of the machine and are manufactured by almost all spark-plug makers. To obviate the use of two separate plugs combination plugs with two terminals—one for magneto and one for the battery—are furnished. These are known as the Edison type, and one of this kind as well as a standard magneto plug are shown in Fig. 89.

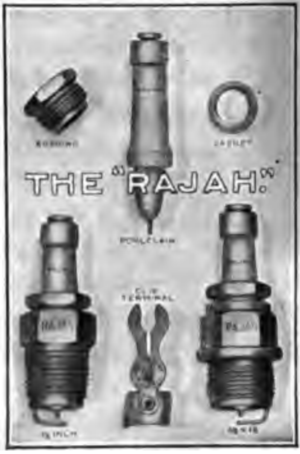


Fig. 87.—Rajah Plugs

A distinct advance in plug construction is found in the "E-Z" plugs illustrated in Fig. 88. These plugs can be instantly removed to clean the points or to replace porcelains without the use of any tools whatever. The lower portion of the plug screws into the cylinder as usual, while the upper portion, consisting of the electrodes and porcelain, slips into the lower shell and is fastened securely by a bayonet lock. Where plugs are frequently removed, or are difficult to get at with a wrench, this is a most excellent feature and cannot be too highly praised. The plug can also be used as a priming cap or relief cock, for the quarter turn required to open it is as easily made as turning on an ordinary cock. The joints are held by asbestos and are guaranteed against leakage; and a test by the writer failed to develop any leak under 350 lbs. air pressure.

Timers are of many kinds and vary from very simple affairs to highly finished and complicated devices, but the function of all is merely to interrupt and complete the current of the primary circuit in unison with the compression stroke of the motor, so that the explosion will take place at the proper instant.

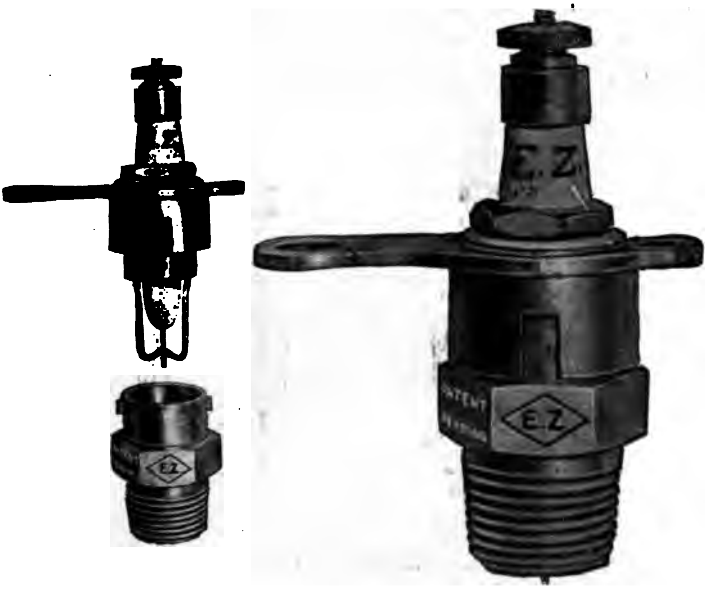


Fig. 88.—"E-Z" Plugs

The simplest form of timer consists of a spring and cam (Fig. 90). In this form of timer the ground wire is attached to the engine frame (*F*) and the other wire to the terminal *A*, on the spring *B*, which is insulated from the engine by the fibre block *C*. The cam *D* is fastened to the valve-gear shaft or to a special shaft operated by the motor and so placed that it will bear against the spring *B* at the instant when the explosion should take place. The cam, touching the spring, forms a connection for the electrical current and hence a spark is produced at the plug within the cylinder. As in order to secure the greatest efficiency from a gasolene motor it is necessary to explode the gas just before the piston reaches the uppermost limit of its stroke, some device must be provided to time the spark to take place at different points in the engine's revolutions. If the spark was advanced enough to give the best results when operating at high speed, it would ignite the charge too soon at low speed and when starting, thus causing pounding, or backfiring, with disastrous results to motor and oper-

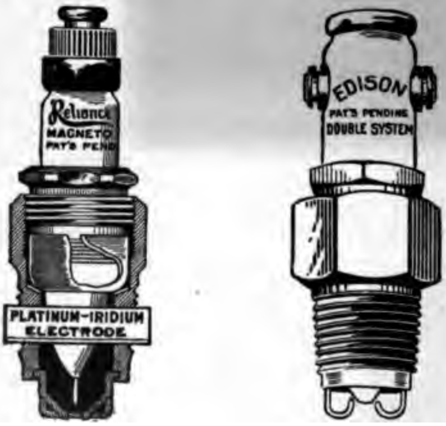


Fig. 89.—Magneto and Edison Plugs

ator. To accomplish this variation, a shifting device known as a *spark advance* is used. This consists in having the spring, or other arrangement, to which the insulated terminal is attached, mounted on a pivot which allows the timer to swing in a segment of a circle around the cam. By moving the timer backward or forward the spark is produced either before or after the upward limit of the piston on the compression stroke.

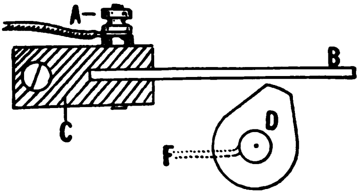


Fig. 90.—Cam and Spring Timer

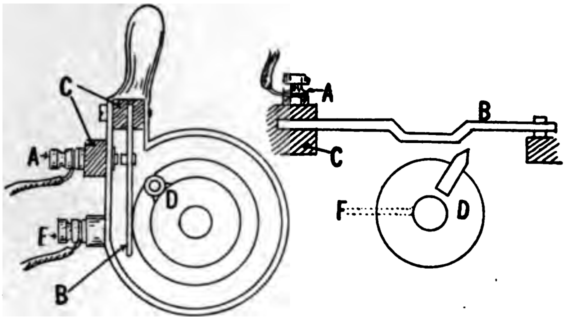


Fig. 91.—Simple Timers

The advance may be operated by a short handle or lever attached directly to it or may be operated from a distance through the medium of rods and levers as in the case of automobiles and other vehicles.

Other forms of simple timers are illustrated in Fig. 91, but in all of these the operation is so similar to the one described that a further explanation is not essential. These simple timers work very well for stationary engines and many of them are in use on automobiles and on marine engines. A peculiar but very satisfactory timer for marine engines is that used on the Tuttle motors and which is illustrated in Figs. 92 and 93. In this timer, *A* represents the eccentric on the engine shaft, which also operates the pump plunger *P*. The eccentric rod *B* is pivoted at the point *C* to the pump plunger, and the upper end is carried out and terminates in a holder *D* carrying a small electric brush, which is backed by a spiral spring shown in the section at *E*, *F*.

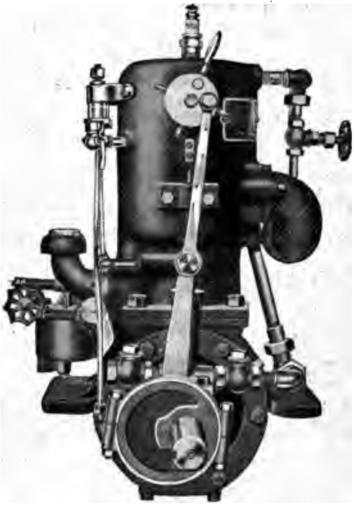


Fig. 92.—"Tuttle" Timer on Motor

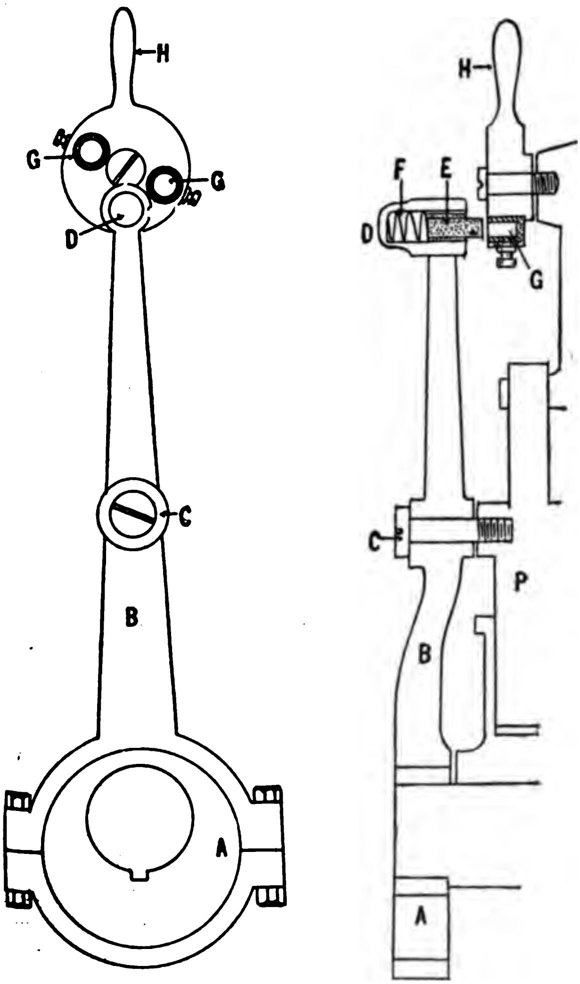


Fig. 93.—"Tuttle" Timing Device

Near the top of the cylinder of the motor there is placed a circular bronze disk, pivoted to the cylinder and provided with metallic inserts surrounded with insulating material ground flush with the surface *G*. The terminals from the wires are fastened to these insulated inserts and the ground wire attached as usual to the engine frame. In operation the eccentric rod bearing the brush which presses against the timer-disk by means of the spring *F*, revolves in a circle of the same circumference as the timer disk. As the brush passes over the insulated inserts an electrical connection is made and a spark produced, but while passing over the rest of the surface no spark is produced as this portion of the disk is thoroughly insulated from the terminals. By moving the disk backward or forward by the lever *H*, the spark is advanced or retarded.

The timers now generally used are enclosed in tight cylindrical cases and are operated by a timer shaft in the case of two-cycle motors (see Figs. 38 and 39, *S*) or are attached to the valve cam-shaft in four-cycle motors. They are of two general styles—roller contact and spring contact—and those two types are shown in Fig. 94. Their operation is so simple and so similar to those already described that no explanation is required, however.

Many more complicated forms of timers are in use, such as Monitors, Unisparkers, Distributors, etc., but these are generally used for special magnetos or dynamos or with certain kinds of engines or very highly developed and complicated motors for vehicle or racing use. Full explanations and directions for their use and operation are always furnished by the makers, and the amateur should never attempt to regulate or repair one of these delicate instruments. A very successful system is known as the Delco, in which one unit embodies a timer, a means for advancing and retarding the spark, and a high-tension distributor. This entire combination is known as the "Distributor" and requires but one coil for any number of cylinders. The distributor is rigidly mounted on the engine and does not rotate as does the ordinary timer. The spark control is effected by moving a lever on the side of the case, and this eliminates all

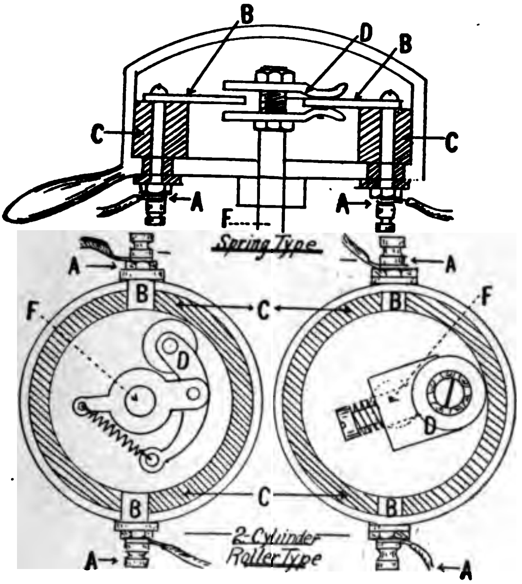


Fig. 94.—Roller and Spring Timers

moving wires and makes possible better mech
construction. The distributor is illustrated in Fi
The distributor is used in connection with a
relay, and a switch, and these are furnished

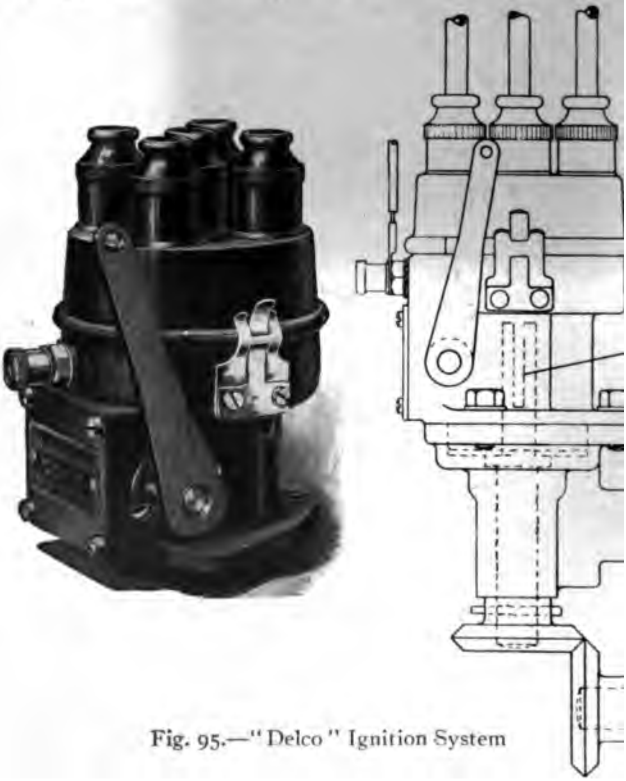


Fig. 95.—"Delco" Ignition System

separately or combined within a common case o
The relay is the apparatus for breaking the pr
circuit and takes the place of vibrators on ord
coils as it acts for each cylinder in turn as the

mutator or timer makes connection. From the ordinary vibrator it differs, inasmuch as it uses but one spark for each contact instead of several. This relay is the only moving part of the entire system, and is very easily adjusted or regulated. This Delco system has been adopted with great success by many motor-manufacturers, and is used on many of the leading automobiles. As a rule, however, the simpler and more accessible the timer and ignition system the better, for nine-tenths of motor troubles are due to faulty ignition and the simpler the entire electrical system is made the more readily can the operator locate his troubles. Small, delicate, or

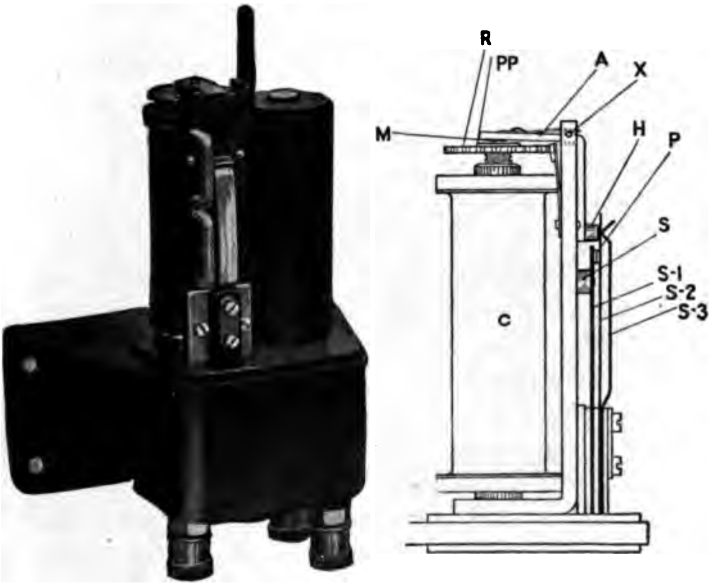


Fig. 95.—"Delco" Ignition System.

intricate parts should be avoided, and in this respect the jump-spark system far excels the make-and-break. In the latter system of ignition a simple primary coil is used and no vibrator or timer is required. This greatly simplifies the electrical apparatus, but the number of small parts, springs, etc., used in the igniter render it liable to many troubles absolutely unknown to the jump-spark ignition.

Several forms of make-and-break igniters are shown in Figs. 40, 96, 97, 98, and in each the operation is very similar. Within the cylinder a stationary electrode *A* is placed, to which one of the wires from the coil is fastened. On the outside of the cylinder there is attached a sliding rod *M*, operated by the eccentric rod *C*. Above this slide rod is a plunger *H*, which is held pressed downward by a stiff spiral spring *J*, bearing against a thimble *I*. Within a recess in the slide rod is an angular dog *F*, held forward by the spring *L*, and which bears upon the lower end of the thimble *I* or plunger *H*, thus lifting it against the force of the spring *J* when the eccentric rod and slide move upward. Fastened to the cylinder is an adjusting screw *G* which bears against the dog *F*, and trips it from the end of the thimble *I* or plunger *H*, thus allowing the latter to be forcibly driven downward by the action of the spring *J*. Between the top of the slide bar *M* and the thimble *I* a rocker arm *C* is placed, which is connected to a spindle *D*, bearing on its inner end within the cylinder a movable electrode *B*. When the slide moves upward, bearing the dog and plunger with it, the rocker arm is forced up to follow the spindle by the spring *K*, thus bringing the movable electrode *B* into contact with the permanent electrode or spark plug *A*, and completing the electrical circuit. As the slide bar reaches its upward limit the screw *G* trips the dog from the plunger, and the latter on its downward travel brings the thimble against the rocker arm *C* and thus snaps the movable electrode *B*

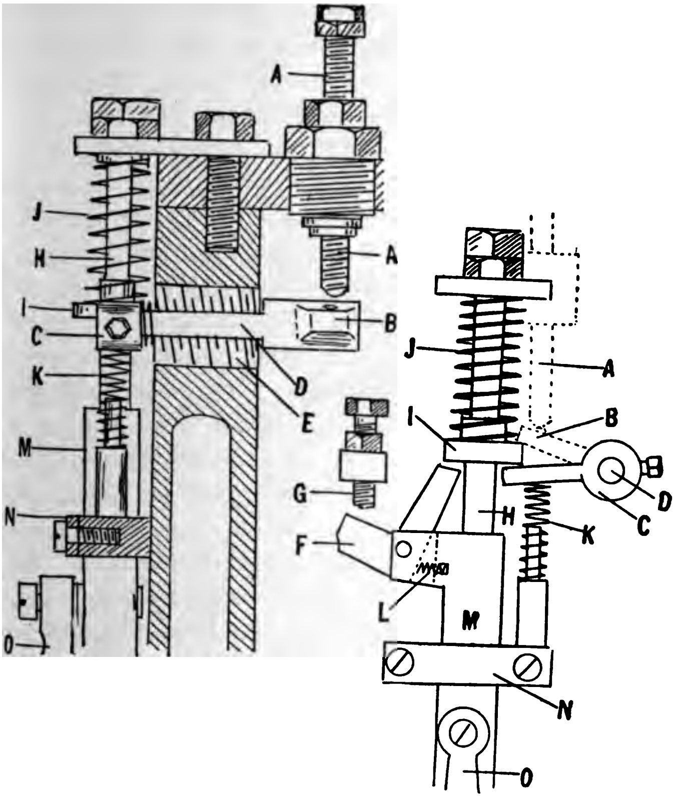


Fig. 96.—Make-and-break Igniter (Operation)

away from the spark plug *A*, creating a sudden, spark between the two.

The igniter may be timed to advance or retard spark by screwing the adjusting screw *G* either u down, and may be still further adjusted by scre up or down the spark plug by loosening the set-screw connects the rocker arm to spindle and allowing it to set varying angle with the mo electrode. In the form of ig illustrated the spark plu screwed into the cylinder and the rocker spindle is ins through the cylinder, enclosed bushing *E*. This form is in use, but it is often essenti remove the rocker electrod repairs or cleansing and to d requires considerable time work. To overcome this diffi several makers have adopte igniter which is entirely self tained in one piece, and which bolts onto the cyl with its inner portion projecting inside. Such an ig is illustrated in Fig. 98, in which the lettering is the as already described and identical with that in Fi The make-and-break system has the advantage of practically water-proof, for it is operated by a tension current and is free from short-circuiting tro For this reason it is a great favorite with fisher

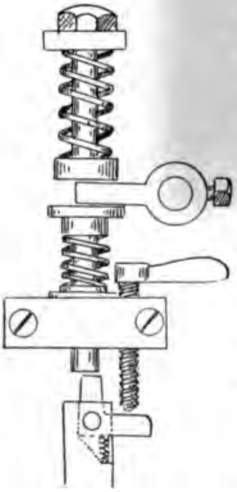


Fig. 97.—Make-and-break Igniter

ermen, and other users of open boats; but its dis-
ntages in my mind more than offset its good points.
sparking points of the two electrodes frequently
me foul with dirt or soot and the low-tension spark
t sufficiently hot to burn this off as in the jump-spark

he continual banging or hammering together of the
electrodes soon wears away the points, necessitating

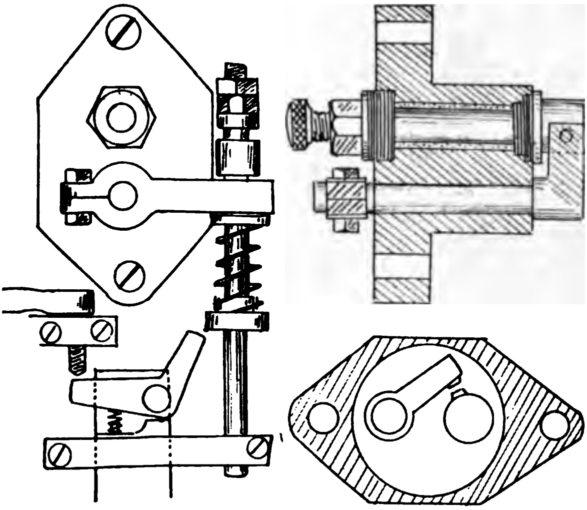


Fig. 98.—Self-contained Igniter

uent renewal and adjustment; the spindle of the
er arm often becomes gummed or stuck with oil
ust, causing missfires or breaking of the spindle or
er; the set-screw holding the rocker to the spindle
ı breaks or wears loose, allowing the rocker to work

on the spindle without operating the interior electrode; springs lose their strength or break; and the mica insulation of the spark plug often breaks, or becomes so filled with oil and soot that it fails to act as an insulation. In addition to all these defects the make-and-break system is very noisy and dirty and requires constant care and attention. Many make-and-break motors that are practically worn out may be given a new lease of life by converting them into jump-spark motors. This is usually very easy and inexpensive If the igniter is of the external type illustrated in Figs 40, 96, and 97, it is only necessary to remove the rocker and spindle and plug the hole; remove the plunger plunger spring, thimble, and rocker spring. Fasten a piece of fibre—to which a terminal and spring is attached —to the slide guide and replace the make-and-break

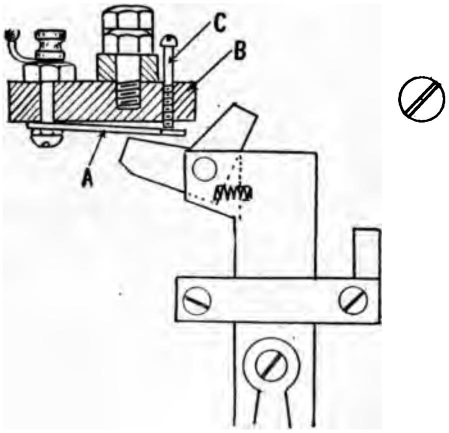


Fig. 99.—Make-and-break Igniter Altered to Jump-spark

plug with a standard jump-spark plug. This transformed igniter is shown complete in Fig. 99. The dog on the slide bar coming into contact with the spring *A* makes the electrical connection and causes a spark in the cylinder. By placing an adjusting screw through the fibre block *B*, as shown in *C*, the spring may be pressed up or down at will, thus retarding or advancing the spark. In the case of motors having a rotary pump, or provided with a self-contained igniter, it is often easier to attach a regular timer to the pump shaft or to a special shaft operated by gears on the engine crank shaft. Of course in any case where the system is changed from the make-and-break to the jump-spark it is necessary to substitute a vibrator coil for the primary coil used in the old make-and-break arrangement.

CHAPTER VII

Mufflers and Exhaust Devices—Governors—Fuel and Fuel Consumption—Oils and Greases—Installation—Piping and Wiring—Gaskets and Packings—Adjustments—General Care of Motors.

A very important part of a gasolene motor is the exhaust. As the burnt gases leave the cylinder at a speed of from 6,000 to 12,000 ft. per minute with a pressure of from 25 to 35 lbs. per square inch, it wil be seen that it is of the utmost importance that the exhaust opening is of ample size to allow the gases to escape without creating a back pressure in the cylinder In four-cycle motors the exhaust valve should also be large enough, and with sufficient lift, to allow the gases to escape quickly and completely during the scavenging stroke. If the exhaust gases were allowed to escape freely into the air there would be little danger of back pressure in the cylinder, but the speed and pressure of the gas would cause loud explosive noises and considerable flame; to overcome the disagreeable noise various devices are used, known as "silencers" or "mufflers." Mufflers and silencing devices are of a great variety of designs and construction, but the object in all is to overcome the noise to the greatest possible extent without creating back pressure. If the exhaust can be quickly cooled after leaving the cylinder or if the gas can be allowed to fully expand before reaching the air, very little noise will result.

Many motors intended for marine use have an auxiliary exhaust chamber as an integral portion of the engine. In the Gray motors this chamber is merely an enlargement of the exhaust opening, but being water-cooled it serves to allow the gases to expand in addition to cooling them, thus materially reducing their pressure (Fig. 100). In other engines the auxiliary exhaust is in the form of a separate chamber or box attached to the cylinder by bolts and is either water-jacketed or arranged with a valve that allows a certain amount of the circulating water to pass directly into the exhaust gases. Such an auxiliary exhaust chamber is illustrated in Fig. 101.

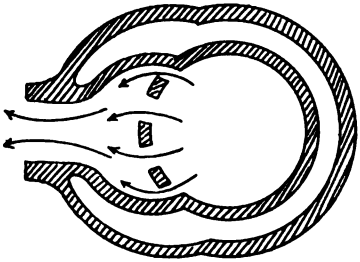


Fig. 100.—"Gray" Auxiliary Exhaust

On marine engines, it is customary to lead all or a portion of the circulation water into the exhaust pipe or muffler and thus cool the gas and reduce the pressure. In the case of vehicle or stationary engines this cannot be done to advantage, as the water used for cooling is generally confined to a definite amount which passes through a radiator or cooling device and is used over and over again. In air-cooled motors there is of course no method of passing water into the exhaust. If the exhaust is merely led into a large cylinder or chamber before reaching the air, the gases will expand and will pass out with but little noise. For stationary use such

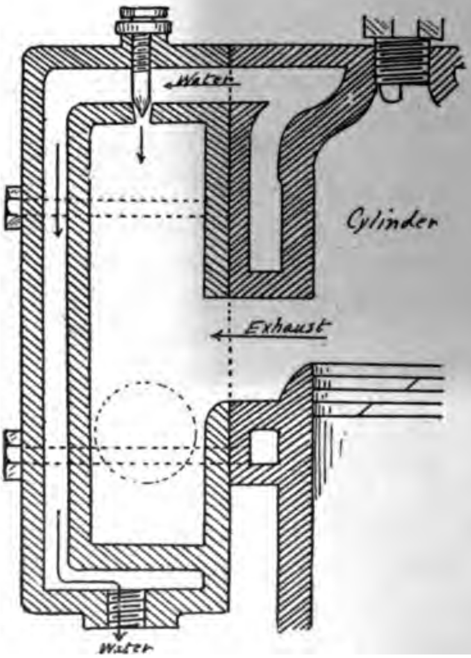


Fig. 101.—Auxiliary Exhaust

expansion-chambers, if of ample size, will usually prove efficient as a silencing device, an old cask or barrel, or even an inverted box, often being all that is required with small motors. In the case of large motors a cement *or brick* chamber is often used, and this can easily be made large enough to permit full expansion of the gases and practically eliminate the sound of the explosions. In marine service there is often an under-water opening to the exhaust, but before leading the exhaust outboard an expansion chamber of ample size must be connected with the engine. With two-cycle motors there are many objections to the use of an under-water exhaust. The exhaust port being open during a considerable portion of the operation of the motor, combined with the fact that the explosive impulse and the inrushing fresh charge are the only methods of carrying off the burnt gases, often results in water or steam working back into the cylinder.

In a four-cycle motor the exhaust valve is closed against any back pressure during the entire intake stroke, and the burnt gases are forced out by the pressure of the piston during the scavenging stroke. For these reasons there is little chance of water or steam getting into the firing chamber. Wherever an under-water exhaust of any kind is used, however, it should be provided with a relief cock at its highest point of piping, as well as a drain cock at its lowest point; and it is also good practice to provide a three-way cock or valve at some point of the pipe in order that the exhaust may be turned off from its under-water connections and deflected through an exhaust pipe leading to the air above the water line. The valve connecting the under-water exhaust should always be turned off when the engine is to be idle for any length of time, for no matter how carefully the exhaust is installed or how far above the water line the motor may be, there is always a chance

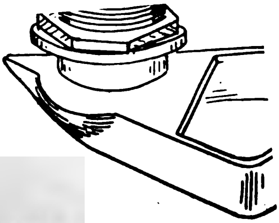
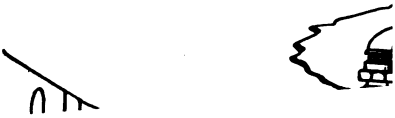


Fig. 102.—"Reid" Underwater

than the water line, thus allowing tl
sink. The relief valve should alway
starting the motor to avoid the possi
water working back into the cylinde
should always be kept open when the n



the pipe it will often draw back into the motor when first cranking it to start.

Until a motor gets well under way it is often very difficult to get good results with an under-water exhaust, and in such cases the three-way valve will prove very convenient, for by its use the exhaust can be deflected into the air until well started, when it can be turned into the under-water connections.

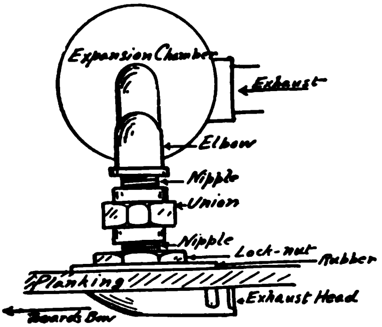


Fig. 104.—Underwater Exhaust Connections

Various methods of leading the under-water exhaust out from the bottom of the boat are in use, but the best method is to use an under-water exhaust head of some sort. A very good form known as the Reid is shown in Fig. 102. This is fastened to the side or bottom of the boat and connected with the exhaust pipe as illustrated in Fig. 103, a thin piece of rubber being placed between the planking and the head to make a water-tight joint. The arrangement of expansion chamber, exhaust pipe, three-way, relief, and drain cocks, and outboard head are shown in Figs. 104 and 105. In place of cooling or expanding the exhaust gases in order to reduce the noise a system may be used by which the rapidly moving volume of gas is broken up into innumerable small jets before reaching the air or by so retarding a portion of the gas that the exhaust reaches the air in a continuous or nearly uniform stream or jet. The fact that a steady stream of exhaust gas makes less noise and commotion than alternating jets renders the exhaust of a multiple-cylinder motor far easier to silence than that from a single-cylinder engine. In order to break up the volume of exhaust gases various devices are used. In the older forms of mufflers the exhaust was led into a chamber or casing filled with stones, pebbles, or coke (Fig. 106) which served to break up the gas into many small jets before it reached the air. Another form, shown in

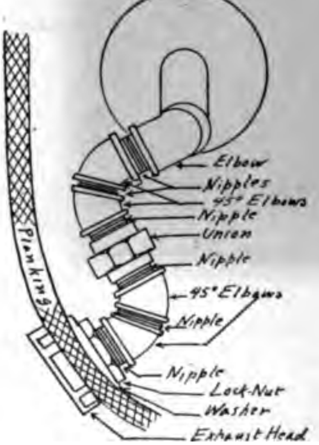


Fig. 105.—Underwater Exhaust Connections

Fig. 107, consists in a casing and a perforated pipe leading from the exhaust port of the engine. The gas, leaving this pipe through the numerous small holes, loses much of its pressure and speed and divides into many jets. As some of these are far nearer the opening to the air than others, the gases finally leave the silencer in a more or less continuous stream. If a second pipe of larger diameter is placed in the muffler, as illustrated in Fig. 108, still better results are obtained. Such mufflers are used considerably, but usually are rather inefficient and often create considerable back pressure. Other forms of silencers consist of hollow chambers provided with segments or plates perforated by small holes and set alternately in the chamber. This style of muffler is shown in Fig. 109, and if properly designed and

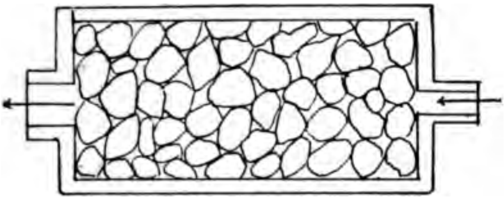


Fig. 106.—Muffler with Pebbles

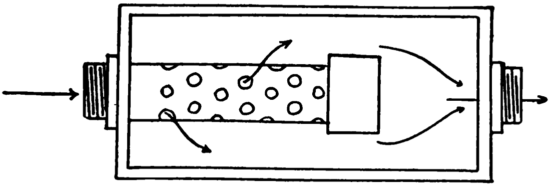


Fig. 107.—Muffler with Perforated Inlet

of ample volume is quite effectual and creates little back pressure.

The well-known Yankee mufflers are constructed with a combination of these two systems. Sectional views are shown in Figs. 110 and 111. The gases entering at *A* partly pass through the perforations at *B* and are partly deflected by the partition *C* and the interior of the pipe *D*, and then expand in the chamber *E*. From this chamber they pass through the opening in the plate at *F* and hence through perforations in the outlet pipe at *G* and into the air through the tail piece *H*. In the Ejector muffler a very different system is used. This is illustrated in Fig. 112. It consists of three expansion chambers, *A*, *B*, *C*, which are separated by conical plates, *D*, *E*, *F*, perforated at top and bottom and arranged in two sets.

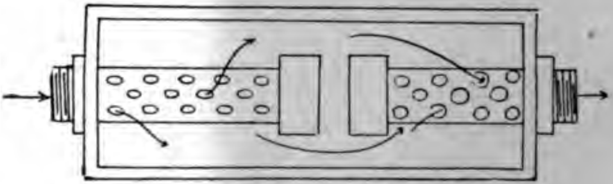


Fig. 108.—Muffler with Perforated Pipes

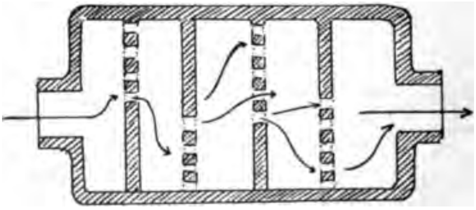


Fig. 109.—Baffle-plate Muffler

The central tube *G*, leading through the muffler, is of varying diameter and a portion of the gases from the exhaust passes directly into the central chamber *B* and hence through the second set of cones *D*, *E*, *F* (2), before the gas which enters the first chamber *A* has passed through the first series of cones *D*, *E*, *F* (1). A small portion of the gas is also led straight through the central pipe *G* to the outlet at a very high velocity. This creates a partial vacuum in the third chamber *C*, and the gas moves rapidly from the second chamber *B* to fill the partial vacuum in the chamber *C*. The forward movement of the gas through the first and second chambers *A*, *B*, to the third *C*, causes a sudden expansion which removes the heat from the gases and reduces the

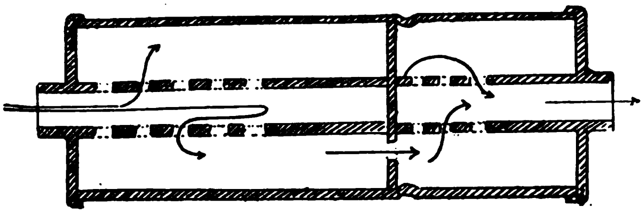


Fig. 110.—"Yankee" Auto Muffler

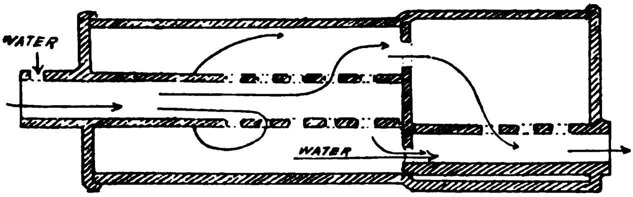
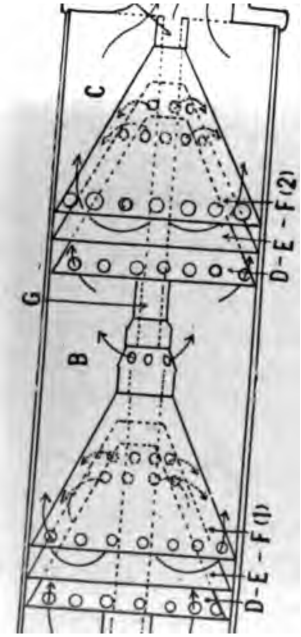


Fig. 111.—"Yankee" Marine Muffler



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', into the chamber *E*. The hot gases ıter instantly lose their heat and pressure that the cooled gases then issue quietly ber by the outlet *G*. Any excess of water · by a drain cock *B* at bottom of silencer, rectly to the bot- at. The Thermex in a similar man- trated in Fig. 114. ɜr forms of excel- re in use, and new stantly being de- ıt on the market. ıich the gases are or whirling motion isfactory; and si- een used in which ː led into a casing ıe fly-wheel which, d with fans or ıs a blower. Whatever style of muffler, ɔansion chamber is used, care should be ː the same of ample size to accommo- ıst gases without back pressure. A vol- imes the square of the piston diameter ɛe will usually be large enough, but even ɜt conditions the perforations or other muffler will frequently become clogged ust and the silencing device and exhaust be frequently examined and cleaned, ı excess of oil is used.

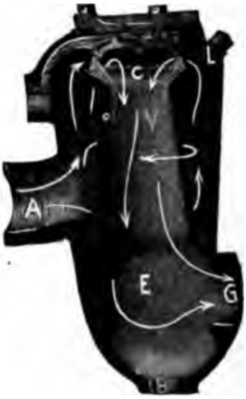


Fig. 113.—"Hydrex" Silencer

Whenever a motor is used under conditions of varying load or work, some method must be used to prevent the engine from racing or speeding up when running free and at the same time allow it to operate at its maximum speed and power when working. Such devices are known as governors, and are used principally on stationary motors. Many large marine motors as well as numerous vehicle motors also use governors, and their use adds much to the life and efficiency of any motor of considerable size and power. There are various methods of governing, the principal kinds being Hit-or-miss, Throttling, and Varying Ignition. In the hit-or-miss the action of the governor is to shut off the fuel supply, open or close the exhaust valve, shut off ignition, or disengage the valve mechanism. In the throttling method the fuel supply is reduced or the explosive gas throttled. In the varying-ignition system the governing is accom-

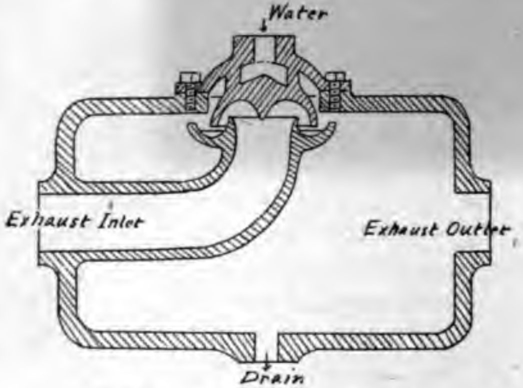


Fig. 114.—"Thermex" Silencer

lished by cutting off the current from the sparking levice or by varying or timing the point of ignition. In Fig. 115 is illustrated a form of governor which perates by preventing the exhaust valve from opening. Vhen the speed of the engine exceeds its normal limit, he balls *A* move outward, causing the cam *B* to be oved to the right by the action of the dogs *C* on the governor arms *D*, which are held in a grooved collar *E* on the sleeve *F*. The end of the cam *B* is thus prevented from acting on the roller *G*, until the motor falls to its normal speed, thus preventing the valve mechanism from operating the valve. Ordinarily the cam is held in position by the springs fastened to the governor balls, which hold the cam against the shoulder of the bearing *I* of the cam shaft *J*.

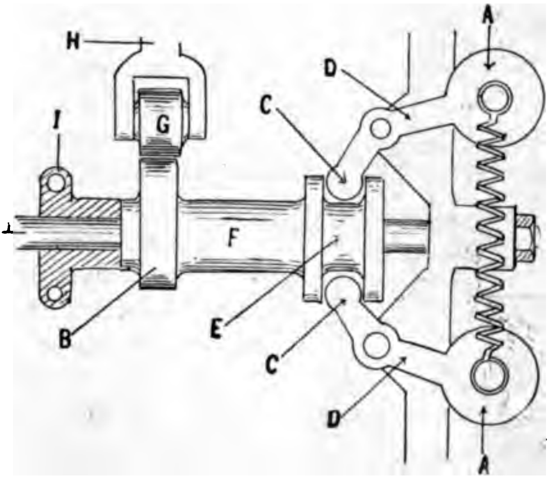


Fig. 115.—Exhaust Valve Governor

Another form of governor, shown in Fig. 116, may be used in connection with any of the governing methods mentioned, but is particularly adapted to throttling methods. The two balls *A*, *A* are rotated through any convenient method of connection with the motor, and in the illustration are represented connected by bevel gears *B*, *B*. As the speed of the motor increases the balls swing outward as indicated by the arrows, thus compressing the spring *C*, and pushing down the stem *D*, by means of the collar *E*; as the rod moves down, the valve *F*, at its lower end, moves past the holes *G*, *H*, which admit the charge of vapor, and thus gradually throttles the charge that passes to the engine through *H*.

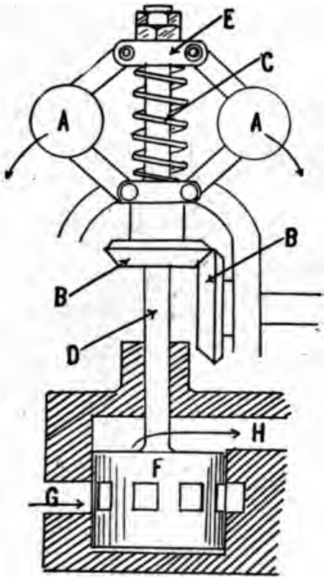


Fig. 116.—Throttling Governor

In Fig. 117 is shown a governor which operates on the hit-or-miss principle. When the motor races or runs beyond the normal speed the action of the balls causes the blade *A* to move away from the notched valve lifter *B*, thus throwing the valve out of action. A governor of the inertia type is illustrated in Fig. 118. In this form, if the engine attempts to run above normal speed, the lower end of the double lever *A* will be depressed by the cam *B*, and the valve lift *C* will be thrown out of engagement with the shoulder *D*, thus preventing any action of the valve until the motor speed drops to normal. Various other forms of governors are in use and these may be attached to a bracket fastened to the engine frame or may be bolted to the fly-wheel or cam shaft. In the Twentieth Century motors a centrifugal governor is fastened to the fly-wheel and through properly adjusted springs and rods is connected with the carburetor throttle. Governors are usually properly adjusted to give the best results when the motors leave the makers; and unless they become loose, broken or worn, or very evidently out of adjustment they should not be meddled with. As most governors depend to a large extent upon spring action, any rust, corrosion, or dirt on the latter is liable to affect the operation of the governor, and care should be taken that they are kept free from dirt and rust. They should also be frequently lubricated, but good machine oil and not cylinder oil should be used *for this purpose.*

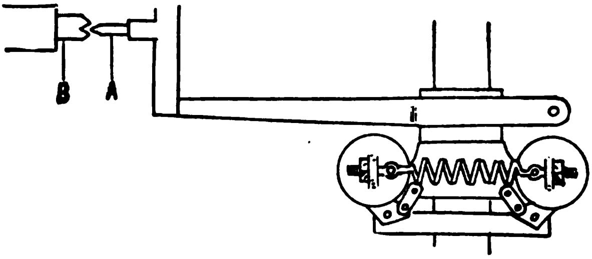


Fig. 117.—Hit-or-miss Governor

Various fuels are used in operating internal-combustion engines and practically any grade of gasolene, benzine, or naphtha may be used to operate a gasolene motor with slight variations in carburetor adjustments. Poor, stale, or dirty gasolene will often give poor results, and as a rule the lower grades are not so economical as the better grades. Moreover, poor fuel results in an excess of carbon and soot and should be avoided as far a possible. Many gasolene motors will run very well o denatured alcohol or kerosene if first started with gasolene. There is really but little reason for using these a fuel, however, for gasolene gives so much better results and so much less soot and carbon that it more than makes up for the additional first cost. Sometimes, however, the operator of a motor will find himself short

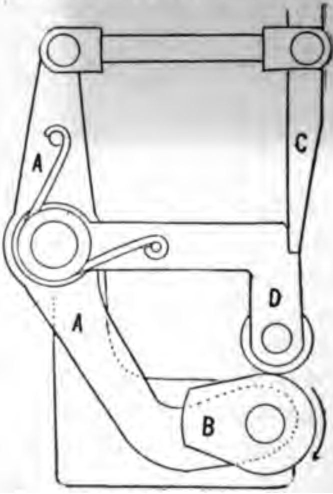


Fig. 118.—Inertia Governor

of fuel where no gasolene can be purchased. At such times, if the motor is started and well heated on gasolene, kerosene or alcohol may be used. It is always a good plan to carry a small quantity of your regular gasolene for use in an emergency, and this should never be used until absolutely necessary. The fuel consumption of a gasolene motor depends a great deal upon the care with which the carburetor is adjusted in order to use the minimum amount of fuel to obtain the best results; the accurate timing of valves and ignition, and the original design and construction of the motor. A two-cycle motor will use more fuel than a four-cycle, and a multiple-cylinder motor will use more than the same number of separate cylinders. Another item which enters quite largely nto fuel consumption is the temperature of the cylinder. The best results are obtained when the temperature of he water in the jacket is kept at about 160 degrees ahrenheit. With this temperature, high-grade fuel, nd careful operation the average engine will consume bout 1 1/5 pints of gasolene, or about 15 ft. of natural as, per horse-power per hour under full load. Engines hat will burn gas satisfactorily will usually burn gaso-ene, and *vice versa*, but it is best to have the motor rranged to consume a certain kind and quality of fuel. Many manufacturers provide devices for using kerosene n gasolene motors; and if kerosene is to be used it is ar better to use such a device, or else purchase a regular il engine, than to try to operate a motor intended for gasolene or gas by crude oil or kerosene.

Many operators of gasolene engines give very little are to the oil and grease used as lubricants. This is

also, a heavier oil can be used tha
even the best of gasolene-engine cy
up in cold weather. Many moto
or cylinder are so badly worn as
will operate very successfully if
of oil, and in two-cycle motors a
oil or grease on the bearings result
pression and more efficient servi
steam-engine oils should never be
cylinder. The terrific heat in the
any but oils made especially for t
or low-grade oils will form excess
Oil is cheaper than motors and t
market is none too good for the
Machine oil is very good for exte
purpose is superior to cylinder oil,
used it should be of a high grade t
stick.

grease should be smooth, clear-colored, clean and soft in any weather. The hardness or softness of a grease used should be determined by trial, and any reputable manufacturer of oils and greases will gladly furnish samples of the various grades. The grease used should be heavy enough so that it will not run and spread, and should be soft enough to feed easily and regularly through the grease cups. The oil used should always be strained before being placed in the lubricators, and if at any time the oil is found to contain any trace of grit or dirt it should be at once discarded and all oilers, oil-pipes, and bearings thoroughly cleaned with kerosene and gasolene before using new oil. The amount of oil to be fed to any motor, or to any part of a motor, depends largely upon the make, the age, the care, and the work of the engine as well as upon the grade of the oil. A new engine should be given a liberal supply of oil until well broken in, when the supply can be cut down somewhat. Too much oil will cause soot and carbon, but too little will result in wear and cutting, and of the two evils it is far better to use too much than too little.

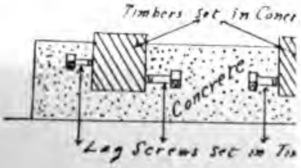
When stopping the motor the oil should always be turned off, as otherwise an excess may get into the cylinder. If a mechanical force-feed oiler is used it will take care of itself in this matter. An excess of oil is readily determined by smoke from the exhaust, and a smell of burning or hot oil. If the proper amount of oil and a correct mixture of fuel are being used, the exhaust will be almost colorless or of a faint bluish tint. If too much oil is used the blue will increase until a dense bluish or *yellowish* smoke issues from the exhaust. It the mixture of air and fuel is too rich—that is, contai too much gasolene—the exhaust smoke will be eith black or dense and white with a sharp, choking, punge odor.

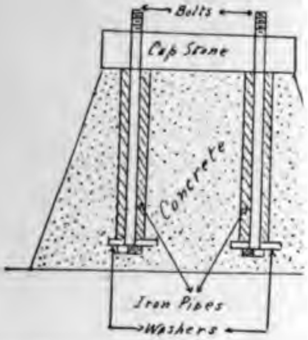
Most engine-makers furnish directions as to t proper amount of oil to be fed the various parts, a these should always be observed. Few moving pa of a motor require less than six drops per minute a few need more than fifteen or twenty, but in wint the adjustment of the lubricators must be altered suit weather conditions in order to supply the prop amount of oil.

The installation of a gasolene motor seems a ve easy matter, but really many excellent engines fail give proper service or satisfaction owing to careless improper installation. In vehicle motors this fault not common, as the makers of motor-propelled vehic install the motors themselves and usually see that it properly done. Stationary motors that are ma factured mounted on trucks, frames, or skids are a usually free from faulty installation, but station motors set up by the purchaser and especially mar motors, are often so badly installed that it is surpris that they work at all.

The first consideration in installing a motor is the b For stationary engines the character and material of t beds depend largely upon the space available, t material at hand, and the location. Brick, sto cement, and timbers all make good beds, but perha the most satisfactory method is to make a good so bed of concrete in which timbers should be embedd just far enough apart so that the bed-plate of the motor may be bolted to them. The timbers should be of ample size, and, to hold them firmly in the cement or concrete, spikes or bolts should be driven into them at intervals before burying in the cement. The cement bed, as well as timbers, should be smooth and level, but a space under and around the motor may be made depressed to catch any water or oil, and drains may be led from this. If after finishing the bed the timbers are found out of level, they may be easily levelled up by thin shims, or bits of wood or metal, placed between them and the engine bed-plate. In placing the motor care should be taken to see that it is so placed as to afford the greatest facility in reaching any and all parts of it and at the same time it should occupy as little space as possible. The engine may be bolted to the bed either by lag-screws through the holes in the bed-plate and well set into the timber, or by bolts put through the timbers before embedding. The bed-plate may then be set over these bolts and held in place by nuts. In either case washers should be placed between the head of lag-screw and engine bed-plate or underneath the nuts. The screws or nuts should be screwed in gradually, first at one corner, then at another; and one bolt or screw should never be fully tightened up before setting up another, as this will often bring an unequal strain and cause a crack or break in the engine bed-plate.

For large stationary motors the beds should be made of solid concrete or bricks set in concrete, and on top of this a flat heavy slab of flagstone or granite should be placed. The bed should be carried down to hard-pan


Timbers Set in Conc
Concrete
Lag Screws Set in Ti


Bolts
Cap Stone
Concrete
Iron Pipes
Washers

should then be embedded in the cement. Such a method is shown in section in Fig. 119.

Mufflers and exhausts on stationary engines should be well covered or protected with asbestos, for they become very hot and are liable to cause bad burns or even set fire to some object that happens to come in contact with them. Exhaust pipes, where led through a wooden wall or partition, should be protected, and a metal collar should be used over the hole with a space of at least one inch between the pipe and the nearest wood. The outer end of the exhaust should be led away from all surrounding objects or walls and should never lead into a chimney, water or steam pipe, smokestack, or other confined space. If this is done unburnt charges of gas may enter and later explode by flame or heat with serious results. If a wooden bed is used it should be firmly mortised or bolted together and should be securely fastened to the flooring or ground. Many engines are given far too light a bed, and when under full power will jump and vibrate tremendously. A good bed should be strong and steady enough to hold the motor down immovably under its highest speed and greatest load.

When installing a marine engine the method is governed to a great extent by the boat, the timbers, and the accessibility of the location. Timbers for a boat engine's bed should be of well-seasoned hardwood of ample size and strength, and should be securely bolted to ribs and keel, *but not to the planking*. A very good plan is to use two long timbers running lengthwise, or fore and aft, of the boat and fastened to the ribs. Across these the bed timbers should be bolted and these should also be securely fastened to the keel. In a flat-bottomed boat timbers may be set across the boat, bolted to keel and sides, and the engine-bed bolted lengthwise of these (Fig. 120). This method takes the jar and vibration from the floor boards and planks. Great care should be taken in getting a marine engine level and in absolute line with the shaft; a very slight deviation will cause enough friction on the shaft to stop the engine or hold it down to only a fraction of its speed and power. I have seen a ten-horse-power motor that could not be turned over more than one explosion owing to a bend in the shaft so slight as to be scarcely perceptible to the eye.

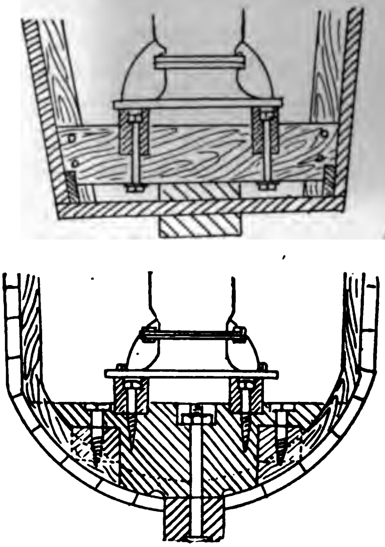


Fig. 120.—Engine Beds in Boats

Where it is difficult or impossible to get a perfect alignment, or where there is a constant vibration or motion, the shaft should be connected through a universal joint. Flexible unions, elbows, joints, and stuffing boxes may also be used if desired. In vehicle construction with a shaft drive universal joints cannot well be avoided, and in many high-powered and racing boats they are also used to great extent; but it is better to avoid flexible connections as far as possible, as they are expensive, cumbersome, and must be given considerable care if they are to prove efficient.

The exhaust piping in a boat can be so readily cooled by admitting a part of the circulating water that there is no excuse for its ever burning or scorching anything, but nevertheless it is a good plan to have it well protected and led in such a way that it will not be in the way of people passing to and fro. A marine motor, more than any other, should be handy and accessible and ample room should be left on all sides to allow it to be adjusted, taken apart, or cleaned readily, and the drain cock in base should be within easy reach. It is usually most convenient to have the exhaust on the port and the intake on the starboard side where the operator sits behind the motor, but the arrangement of such matters must be guided by the conditions in each particular case. In installing any engine the exhaust silencer should be as near the motor as possible, and the exhaust pipe should be as short and with as few bends and turns as can be arranged. Where right angles *must* be made in an exhaust pipe two forty-five-degree elbows should be used instead of one common elbow, and tees should be avoided as much as possible; they always ha pockets which are a nuisance. Connections as far possible should be made with flanges or flanged unio as ordinary screw unions and right-and-left coupli soon become so foul and corroded as to be impossi to disconnect. The exhaust in a boat should always so arranged as to slant downward from the motor

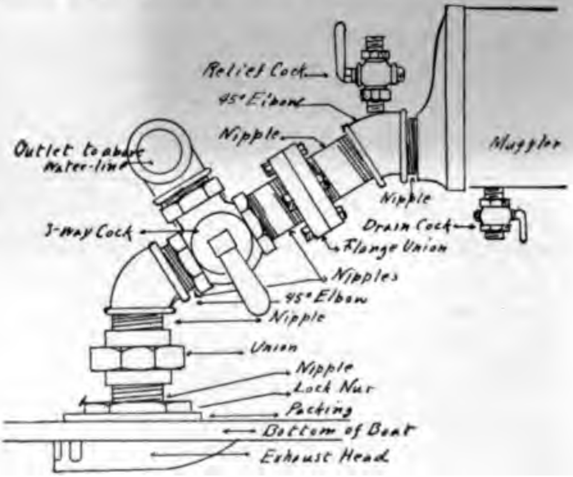


Fig. 121.—Marine Exhaust properly Installed

the outlet, for even if far above the water line a wa may now and then wash into the exhaust.

If a long exhaust pipe is unavoidable it should gradually increased in size, and it is a good practi to always use a larger-sized pipe at every turn of t exhaust pipe beyond the first. For connecting up exhaust pipe lead and oil should never be used, as soon burns out and either leaves a leaky joint or cemen the joints together into a solid mass. Cylinder oil and graphite make an excellent joint, and even linseed oil and graphite is very good. Where a solid and permanent job is desired the joints may be made with red lead and molasses, or with litharge and glycerine, or with a cement composed of sulphur, iron filings, and sal-ammoniac mixed into a thin paste with water. Well-fitting threads may also be well cemented together by the use of sal-ammoniac and water alone. Where the boat is intended for salt-water use the exhaust pipe should be of galvanized iron, and this is far better than black iron even where used around fresh water or for stationary motors. A sample of a well-installed marine exhaust is shown in Fig. 121. This illustrates an under-water exhaust, while Fig. 122 shows methods of exhaust piping when above the water line. In Fig. 123 is shown the method of properly piping a stationary exhaust where it was carried a long distance and several turns had to be made.

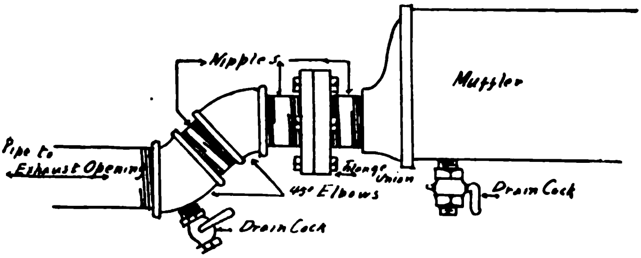


Fig. 122.—Installation of Exhaust above Water-line

The water-circulation pipe connections should be made with care, for a small air leak in the intake will often cause failure of the pump, and a leak in the outlet is very messy and disagreeable in a boat and wasteful of water in stationary or vehicle use. Brass pipe is advisable in marine work, although for fresh-water use galvanized pipe answers very well. Connections on water pipe may be made with white or red lead and oil, and common unions may be used, although for many reasons flange unions are better. Turns in water pipe are not as objectionable as in the exhaust, but are to b avoided as far as possible, and the piping should alway

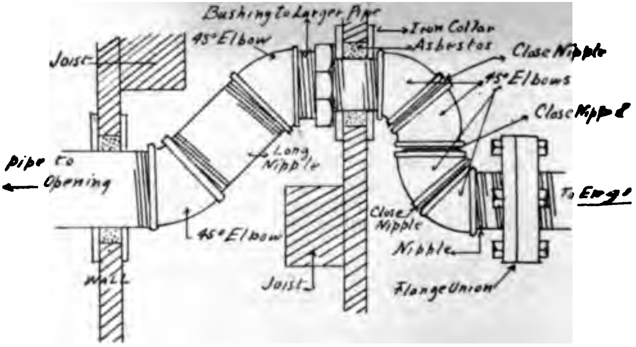


Fig. 123.—Installation of Stationary Engine Exhaust

be provided with drain cocks at the lowest points in orde to draw off the water in cold weather. Hose connec tions are bad and should never be used where they ca be avoided. They are uncertain at the best and soon ro Moreover, they become soft and are liable to collapse with suction and shut off the water supply, while piece of the fabric or rubber are always likely to work loose and get into the pipe, valves, or pump and cause trouble At the intake of a boat's water system there should be strainer, and a cock should also be provided for shutting off the intake when not using the boat. Many a boat has filled and sunk through a loose or broken connection and lack of a valve to shut off the water. In connection with the water system, where a small part of the water is turned into the exhaust, a three-way valve will be found most useful. A valve of this sort, made by the Detroit Lubricator Co., is illustrated in Fig. 124. By the use of such a valve any amount of water desired may be admitted to the exhaust or it may be turned off completely and all the water led overboard direct.

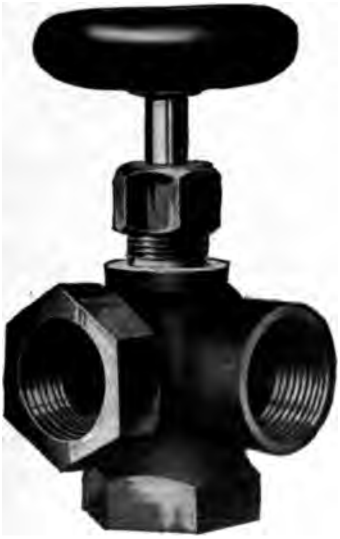


Fig. 124.—" Detroit " Three-way Valve

In making up the gasolene pipe more care should be used than in any other part of the various pipes and connections. A small leak in this pipe may fire and destruction or even in loss of life, fc drop or two of gasolene now and then will enough gas in a boat or small building to blow it In open boats the greatest danger lurks in th around the tank, but in cabin boats, or in buildings, the entire place may be filled with will explode the moment a flame is brought int with it. Even in motor vehicles a leak in a pip may allow gas to form which will ignite by a cuited wire or a carelessly dropped cigar or ciga nearly every case of gasolene fires or explosic motors can be traced to a leaky connection or

All joints in the gasolene pipe should be m shellac or with common laundry soap, as any containing oils is useless. Where brass pipe is connections should be carefully threaded and up tight. A good, clean, new thread will hold without anything else. Where a flexible tube should be of soft copper and all the unions or co should be soldered or brazed in place. Where a pipe is subject to any vibration or jar a loo should be provided to absorb vibration (Fig. and the pipe should frequently be looked over f or cracks. A cock should always be placed at so that the supply may be readily shut off (Fig and a strainer should be provided to catch any dirt in the gasolene (Fig. 125, *H*). Lead or pipe is to be avoided. It is easily bent or c apt to be punctured, it corrodes and forms s sediment in the gasolene, and in case of fire i melts, thus allowing more gasolene to run out and feed the flames.

Careful attention should also be given to the gasolene tank. It should be of copper or galvanized iron of ample capacity and the feed pipe should be connected a short distance above the lowest portion. This will prevent any dirt or water in the bottom of the tank from working into the feed pipe. At the lowest point in the tank there should be a drain cock from which the collection of sediment and dirt may be drawn from time to time (Fig. 125, *D*). This drain in a boat should lead overboard and thus avoid danger of the gasolene getting into the bilge-water. A cock should also be placed in the feed pipe close to the tank so that the supply may be entirely shut off at any time (Fig. 125, *E*). The filler hole in the tank should be covered with a screw top (Fig. 125, *B*) and a small air vent made in *the side of this cap* (Fig. 125, *C*). This will allow the fuel to flow freely and also prevent dust or water from entering the

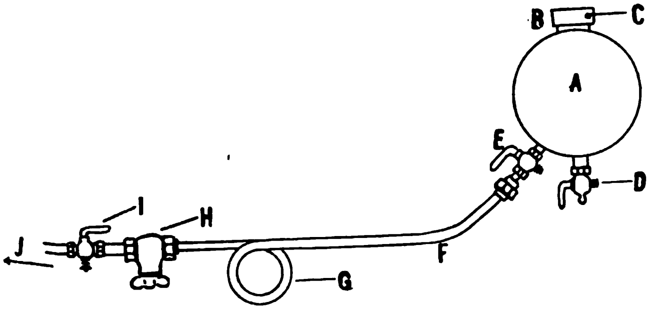


Fig. 125.—Gasolene-Pipe Installation

tank. The tank on stationary engines should l bottom at least six inches above the highest carburetor, and on marine or vehicle motors it be high enough so that any motion of the b sea-way, or of the car when hill-climbing, will n the carburetor above the lowest point of th

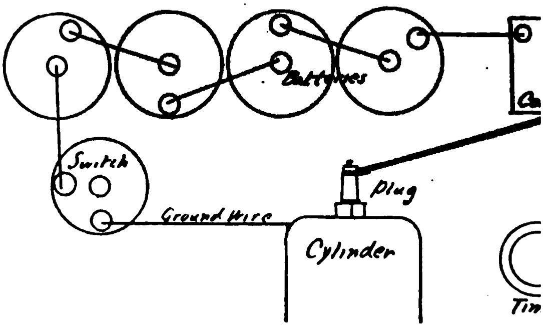


Fig. 126.—Wiring Single-cylinder Jump-spark with Ba

Every tank should also be provided with splas inside to prevent the liquid from swashing ab causing irregular feed.

To many motor-owners and users the que electrical wiring is a very serious matter. I cases one must be a good electrician as well as n to wire up a motor, but in the majority of c wiring is comparatively simple and easy. A des of wiring is of little use, for it is far easier to diagram or design a new one suited to particular ments by the aid of others. The makers of most furnish full wiring directions and diagrams wi engines; but as motors frequently require new

new systems are installed, or old motors without directions may be purchased, diagrams for wiring the various types of motors, as well as several systems of both battery and combined battery and magneto, are illustrated in Figs. 126 to 136.

In wiring for a motor, whether for marine, stationary, or vehicle use, the best materials only should be used. About 80 per cent of motor troubles are due to ignition, and a large proportion of these are due to poor or faulty wiring. Too much care cannot be taken to see that all materials are perfect, all joints well made, and that the wiring as a whole is as well done and as free from the chance of injury, breakage, or short-circuiting as possible. For primary wires in the jump-spark system, or for the wiring on a make-and-break engine, fairly

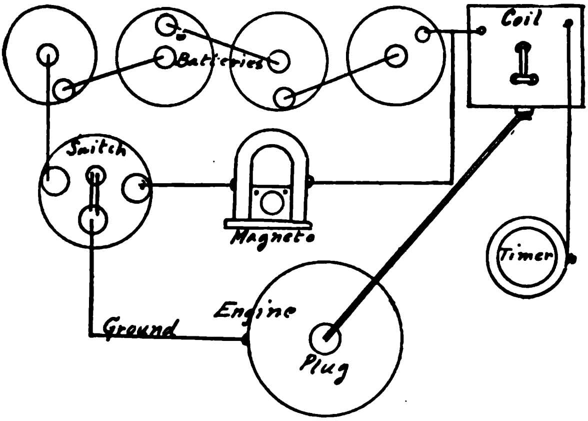


Fig. 127.—Wiring Single-cylinder Jump-spark with Batteries and Magneto

light wire may be used, but this should be of good quality, well insulated, and of the multiple-strand kind. Single-strand wire is very good, but in connection with a motor the constant vibration is liable to break, or partly break, the wire and as this is not visible through the insulation the trouble is often very difficult to locate, especially as the two ends may rub together, causing intermittent or weak connections. Where staples are used to fasten wires to seats, rails, or any woodwork, they should be fibre- or leather-covered, or when these cannot be secured, a bit of rubber, leather, or even cloth may be placed between the wire and the staple. Two wires should never be confined under the same staple, for if the insulation becomes worn or broken, short-circuiting is almost sure to result. Have as few joints in a wire as

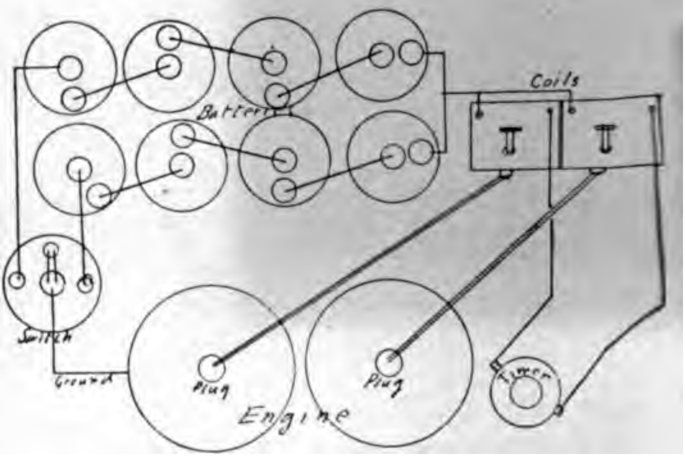


Fig. 128.—Wiring Two-cylinder Jump-spark with Batteries only

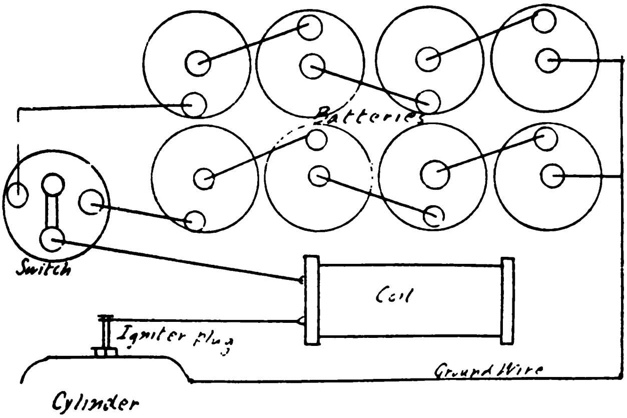


Fig. 129.—Wiring Make-and-break with Batteries

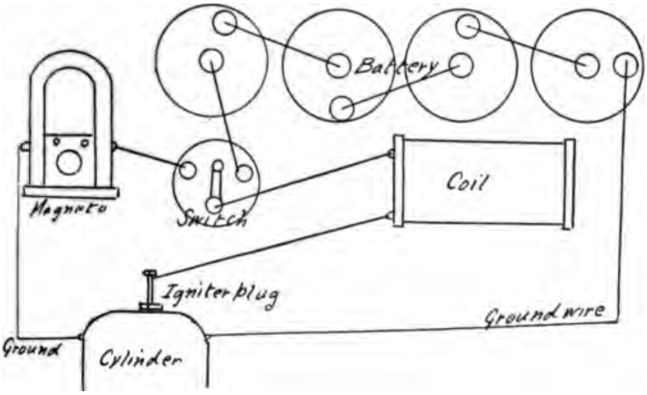


Fig. 130.—Wiring Make-and-break with Batteries and Magneto

possible, and when making a joint have the strands bright and clean and after being twisted firmly together they should be soldered. Soldering is not absolutely necessary, but it is safer, and with the modern soldering compounds, which can be used with a match or small torch or lamp, it is very easy to solder all joints. Whether the joint is soldered or not, it should be well wrapped with several layers of adhesive rubber tape.

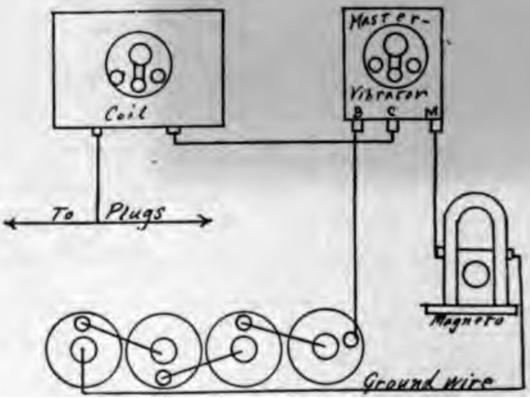
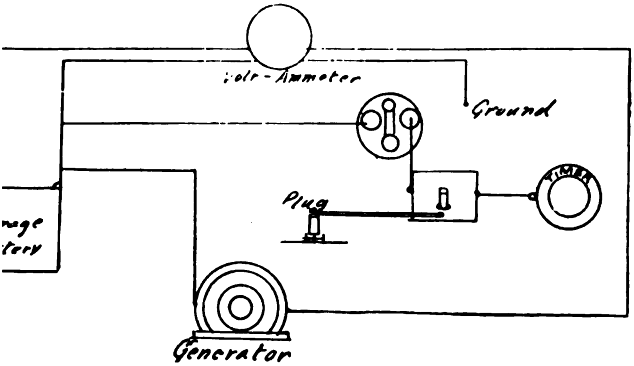


Fig. 131.—Wiring any Number of Cylinders with Master Vibrator

Secondary wire should be of the highest grade and where there is dampness or grease it should be led through a metallic or fibre tube or casing. Grease, water, and oil will in time destroy insulation and allow short-circuiting, and therefore all wires should be as thoroughly protected as possible. In marine work it is a good plan to run the secondary wires through rubber tubing and in all cases the wiring should be kept as short as possible. Avoid confusion of wires and keep each group separate



132.—"Aplco" System of Wiring with "Floating" Storage Battery

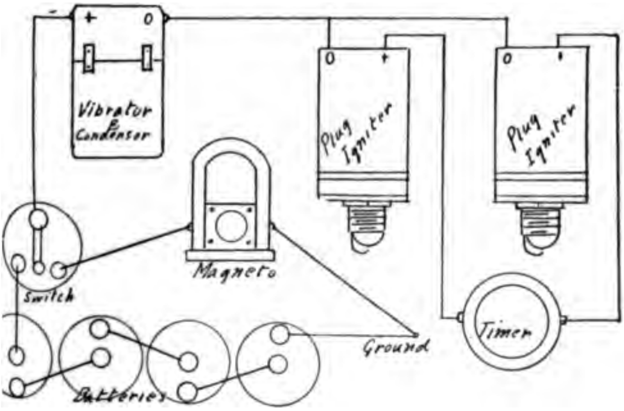


Fig. 133.—Wiring "Perfex" System

as far as possible. If wires are led under or spaces where they cannot be readily seen and f

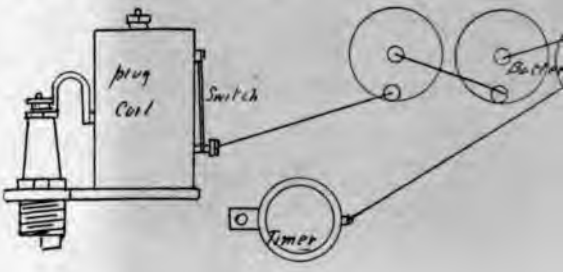


Fig. 134.—Wiring "Perfection" Plug-transforme

it is a very good plan to use various-colored v in that way the wires from one place to another easily traced. If several different-colored wires

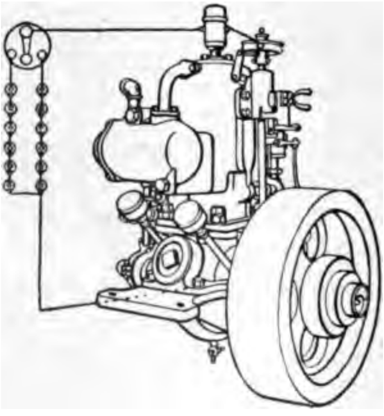


Fig. 135.—Wiring "Connecticut" Plug Coil

available, colored strings or bits of cloth may be f here and there to each wire and this will serve to i

Never lead a secondary and a primary wire the same tube, staple, or insulator, but keep far apart as possible, and never attach either or secondary wires to any metal except at the s. If metal *must* be used, be careful to have the ubly or trebly insulated by winding with tape ıey touch the metal.

terminal connections of both primary and

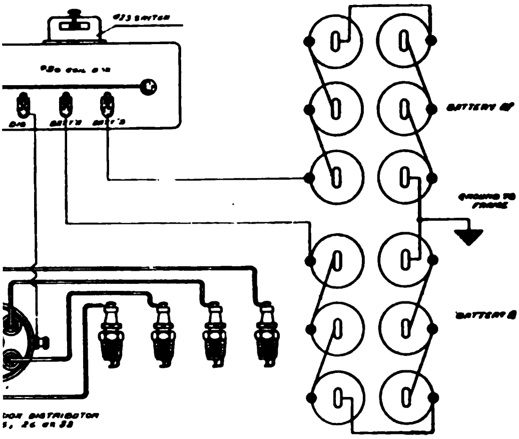


Fig. 136.—Wiring "Delco" System

y wires where they connect with batteries, er, and plug are often sources of trouble and ›e carefully made and frequently examined. styles of battery connectors and terminals are and most of these are excellent. The "Bull ttery connectors, as well as the various spring ıectors, work very well; but those made from a piece of sheet metal and soldered to the wires often break partly off without any external sign of the fracture and in this way cause an interrupted or weak current that is exceedingly difficult to locate. Primary and secondary terminals for the main wires come in a variety of forms and designs. A common form is shown in Fig. 137, which represents the "Reliance" terminal. These may be used by slipping over the nut or thumb screw on the top of spark plug or may be fastened by screwing the nut down over them. Another splendid style of terminal is the "Ball and Socket" form illustrated in Fig. 138. These terminals are designed to be fastened to the wire without solder or special appliances. It is only necessary to cut the wire off square, shove it into the socket, and screw the wood screw in tight. The sides of the terminal are made of spring metal with a recess to fit over the ball adapter or hexagon ball nut furnished as a part of the equipment. The use of the ball-and-socket joint allows free play of the wires in any direction and insures a perfect connection.

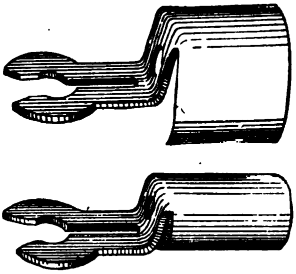


Fig. 137.—"Reliance" Terminals

Terminals which will answer every purpose may be readily made by bending the end of the wire into a loop, twisting it together and soldering it firmly in place.

In repairing, adjusting, or overhauling motors various gaskets or packings will be encountered, and as these are usually broken or injured in getting the joints apart, it is essential that the operator should know how to make new ones and be familiar with the materials to use. Gaskets are rings or sheets of material cut into the form of the parts and placed between two surfaces, such as the two sides of a cylinder head, between the two sides of a union, etc. They are made of paper, asbestos, fibre, metal, rubber, leather, etc. The best material for cylinder-head gaskets and any other places where there is considerable pressure, as well as water or gasolene, or both, is the material known as "semi-bronze";

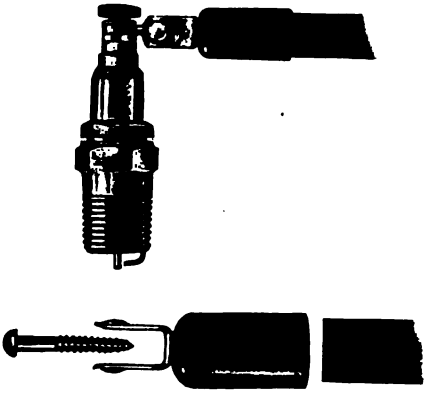


Fig. 138.—" Connecticut " Terminals

this packing consists of a fine sheet of copper-wire gauze embedded in a sheet of asbestos and covered with graphite or black lead. In many places exceedingly thin gaskets must be used, and in such spots tough manila paper well soaked in oil or grease and rubbed with graphite is the best material. Metal gaskets are used between flanges in flange unions, on exhaust connections, etc., and usually come ready-made in various sizes.

Asbestos of itself is a very poor material to use about gasolene engines, as it is frail, is readily soaked by water or gasolene, and is hard to cut or handle without tearing or breaking. In making a gasket the best method is to clean the part to be fitted and then lay a sheet of the paper or other material over it. With a smooth-faced wooden mallet or piece of rounded hardwood, tap all over the surface until the edges of the joints, as well as the various bolt or screw holes, are well imprinted on the material. Then, with a circular punch, cut the holes where indicated and after this is done cut out the edges of the joints. A gasket must never have rough edges that will bind or catch in the joints, and the holes for the bolts or screws must be smooth and ample in size. Rub the gasket with oil or oil and graphite before placing on the joint and then lay upon the surface of the joint carefully. Be sure there are no wrinkles, bits of dirt, or inequalities in the gasket and make sure that it fits perfectly before placing the other part of the joint on it. When all is ready, place the two pieces together and screw home the bolts a little at a time, working gradually, first on one side and then on

:r, but never tightening up all at once on any ›lt.

kings for pump plungers, revolving shafts, stuffing etc., are usually made of cotton wicking or hemp ıg. In making such a packing be sure and clean l the old material, use packing of the proper size, ›roughly before putting in place, and do not pack ght until it has formed a good bearing or seat e shaft or other object. Never use white or red n a gasket or packing of a gas engine unless you oking for trouble. Oil and graphite is the best :al, and unless the packing or the ground joints ·ry badly made or have been abused, nothing is l in addition.

ıdjusting a new motor, or one which has been ly overhauled, you should proceed slowly, doing ing at a time, and remembering exactly how each ment was beforehand and exactly how you have l it. A valve may be ruined by turning it a trifle ght, or a screw thread stripped or a bolt head d off by a slight pressure beyond the normal. ing down or overhauling a motor each part should rked and a similar mark placed on the part of the where it belonged. This may be done by light with a centre punch or by scratches on the paint, l, or metal. In taking apart a four-cycle motor ; most important in the case of the timer and gears. The alteration in position of a single on a gear will throw the entire valve out of ›n. In taking apart such gears always mark the where *they* mesh, with a prick punch or centre punch so there may be no difficulty in placing them together correctly.

Setting the valves properly in a four-cycle motor is an important matter. The exhaust valve should open at about five-sixths of the completion of the power stroke and should close at the end of the idle or scavenging stroke. At the commencement of the next outward, or suction, stroke the inlet valve should begin to open, and both valves should be firmly closed at the moment the piston commences to travel back on the compression stroke. Different motors vary somewhat as to the exact time when valves open and close, but the above is about the average and the finer adjustments can be readily made by set-screws or other devices provided until the best results are obtained.

A gasolene motor should be cared for as carefully as any other piece of fine machinery, and because it uses oil and grease and becomes dirty in use it is no reason why it should be neglected and not cleaned and groomed frequently. A rusty, dirty, or neglected engine is a disgrace to the operator and shows lack of common sense or care. Oil cups and oilers, as well as grease cups should be kept well filled and all excess oil or grease carefully wiped off. If grease and oil accumulates or sticks on, it should be removed by kerosene and gasolene. All unpainted parts should be kept clean and free from rust and well oiled, and all nickel or brass work should be kept brightly polished. If you cannot spare the time to polish and clean your brass it is better to paint it at once and avoid horrid green verdigris. A vehicle motor requires as much care as any other, and because it is out of sight it is all too frequently out of mind as well. Many a splendid motor-car, that is resplendent in polished brass, rich upholstery, and shining paint and varnish, carries beneath its hood a motor so greasy, dusty, dirty, and neglected that it would be a disgrace to the most slovenly fisherman's dinghy.

CHAPTER VIII

TOOLS; EMERGENCY REPAIRS AND MAKESHIFTS; USEFUL HINTS AND WRINKLES; GRINDING VALVES AND GRINDING COMPOUNDS; CARBON-REMOVERS AND CLEANSERS; POLISHES; ENAMELS, PAINTS, ETC.; BELTS AND BELT DRESSINGS; ANTI-FREEZING MIXTURES; TABLE OF MOTOR TROUBLES WITH CAUSES AND REMEDIES.

FEW motor-owners realize the importance of being provided with proper tools, and this is especially true where marine or stationary motors are concerned. Every motor should have a tool box or chest or a tool-roll within easy reach, and the tools should always be kept in good condition and ready for use. Many a motor-operator may be found whose only tools are an old rusty bicycle wrench, a dull or bent screw-driver, and an old claw hammer. Tools are cheap and comparatively few are required. A superabundance of tools is a nuisance, and the aim of the operator should be to have a tool for every emergency and for each particular use, but not to duplicate them. The following tools are really essential in connection with any motor:

A "Stilson" or pipe wrench capable of handling any pipe on the motor; if this cannot be procured, owing to the variation in size of pipes, two or more Stilson wrenches should be on hand.

A monkey or "Coe" wrench large enough to handle the heaviest nuts and unions on the engine or exhaust.

A small "Coe" wrench capable of handling the smallest nuts; a good bicycle wrench will answer for this, or a t of spanner wrenches to fit the various nuts may be ed.

A medium-sized — six- or eight-inch — "Westcott" rench or a set of "S" wrenches.

A pair of combined cutting pliers and tweezers.

A pair of round-nosed pliers.

Small, medium, and large-sized screw-drivers, or a t of screw-driver blades with an adjustable handle.

A small or medium-sized machinist's hammer with und pein.

A half-inch cold chisel.

A centre, or prick, punch.

A hollow punch.

A flat or "bastard" file, a round file, and a three-rnered file.

An assortment of copper and iron wire of various es.

Assorted machine screws. Assorted cap screws and ts. Assorted plain and lock washers. Assorted cotter ns.

In case there are any nuts or bolts which cannot be adily reached with an ordinary wrench, socket wrenches ould be provided, for such nuts or bolts are invariably e ones that need attention oftenest.

In addition to the above tools there are many others ich will prove very useful at times, especially if you pect to make your own repairs. A breast drill with a od assortment of drills is a useful and handy tool, d a bit-stock with various-sized twist drills is also ry useful. By drilling a small hole with the breast ill, a large twist drill will readily bore through iron or brass with an ordinary bit-stock, the larger drill following the small hole very easily.

In connection with the drills, reamers and countersinks should be on hand, and if much metal-boring is to be done a self-feeding chain attachment for the bit-brace should be added. By means of this handy tool large holes can be rapidly and easily bored through iron or steel without any great trouble or strength being required. Hack saws are very useful and in fact almost indispensable, and screw slotters to fit the hack-saw frame will save much time and trouble in using old screws. An exceedingly useful tool is the Vixen milling tool. This is a hardened steel blade with sharp, curved teeth and is used like a file. It will cut ten times as rapidly and easily as a file and will never clog, even when used on lead, copper, or aluminum. New blades may be purchased at a small cost and the old ones recut or sharpened at trifling expense, but under the severest use a blade will usually last two years or more.

Machine taps and dies are very useful and save many times their cost in a season, as well as the trouble of running to a machine shop for every screw thread you want cut. Pipe taps and dies are also handy, but most pipe fittings are so cheap and so readily procured that they hardly pay unless one does considerable pipe-fitting or is a long distance from a dealer in pipes and fittings. Calipers are useful, and an assortment of cold chisels, cape chisels, and punches will prove of great value.

Every motor-owner should learn the proper use and care of tools, for a rusty, dull, or broken tool is worse than none at all, and there is no excuse for keeping tools in poor condition. Around salt water tools rust very quickly, but if greased every few days the corrosion will not cause any trouble. You should not expect to work metal as easily as wood, even with the best tools, and many a good tool is injured or broken by trying o force it. Slow and sure is the way to work metal, nd trying to drill too rapidly is sure to result in broken rills, while using too much force on a nut or bolt will sult in stripped threads or broken bolt heads. A ry light blow with a hammer will often start a nut joint, but wherever the surface struck joins another face a piece of hardwood or a strip of copper or lead ould be placed over it before striking. Great care ould be used in striking cast iron, or a crack or break ll result; high-grade cast iron will chip or crack nost like glass and a hammer should never be used thout wood or soft metal under it when striking cast on. Sometimes an obstinate nut or bolt may be adily started with a cold chisel and hammer, but you ould not use enough force to shear off a corner of the ut. Hold the chisel at an angle against one side of the ut and strike gently. After it is started the burr made y the chisel should be smoothed off with a file. Turentine is very useful in drilling, sawing, or filing metal, nd many tight pipe joints or screw threads will come part easily after soaking a few hours in turpentine. erosene is good also, and in case a pipe joint or thread badly stuck it may be soaked in kerosene and then nited. The burning kerosene will usually expand the int enough to break the corrosion and then by soaking turpentine the joint will be easy to separate.

Sometimes, even with the greatest care, a cap-screw or stud will break off in the hole. To remove the broken piece is often very difficult and sometimes it is absolutely necessary to rebore and thread the hole. Many times, however, the stub may be unscrewed by boring a hole in it and tapping with a left-handed thread of smaller size. By screwing a left-handed screw into this and setting up tight the tendency will be to unscrew the right-hand thread on the broken stub. Many times a bolt or screw thread becomes badly worn or rusted and the bolt or nut will not hold. Usually it is always best to retap the hole and use a new bolt, but in many cases such methods are impossible. At such times the thread may be made to hold like new by slitting the end of the bolt or screw and spreading the sides slightly, or in the case of large bolts by driving in a small wedge (Fig. 139). If the nut is worn and the bolt is all right, the former may be made tight by heating to red heat and then sprinkling cold water around the outer side. This will shrink the nut considerably and result in a snug fit. The application of heat for expanding metal is often very useful, and many joints can be taken apart or put *together* when hot that cannot be started when cold.

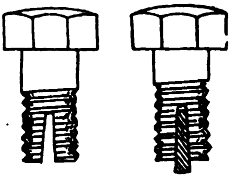


Fig. 139.—Tightening Old Bolt

ose sprockets, cams, wheels, etc., can all be made very ht by expanding the pieces with heat and while still t putting them together and allowing them to shrink a close fit. Sometimes a nut which is not held by a k washer or cotter pin may become loose and give isiderable trouble. This may be easily overcome sawing a little less than half-way through the nut d then springing the two parts close together. A nut ated in this way will hold like a lock nut and will ver loosen (Fig. 140). Care should be taken, however, to cut the slit too deep or too wide, or the threads l be stripped in screwing it on.

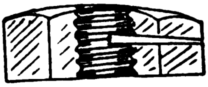


Fig. 140.—Slit Locknut

Very often one requires a pipe-fitting of a smaller or ger size and has no reducer or bushing at hand. At :h times the man provided with pipe taps and dies y make excellent reducers by using short pieces of ndard brass pipe. In brass pipe each size will thread ide for the next smaller size: thus ¼-inch pipe may threaded for 1/8; 3/8 for 1/4; 1/2 for 3/8; 3/4 for 2; 1-inch for 3/4, etc. Iron pipe will not thread so :urately, but in many cases a thread can be cut in n pipe that will answer for an emergency. Pipe-iplings may also be used as reducers by threading the tside for the next larger sized fitting, but they are rder to handle and do not make as good reducers as pieces *of brass pipe.*

In threading brass rods it will often be found tha same sized die as the nut used will not allow the n be screwed on. In such cases the rod should be slig filed down or rubbed with emery before threa Brass has a tendency to bind when it fits tightly, threads on brass can always be made with more than on iron. In using 1/4-inch machine thread nut often advisable to use a No. 14 thread with the pitch in threading bars for the nut.

If you should require a pipe wrench and have no

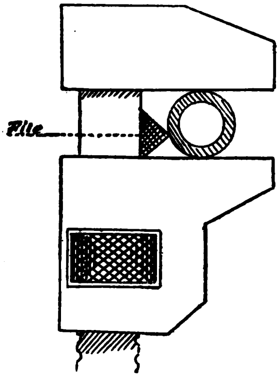


Fig. 141.—Monkey-wrench as Pipe Wrench

hand you can often handle a pipe successfully by pla a three-cornered file in a monkey wrench and this on the pipe (see Fig. 141). Old files that are clo and dull may be readily cleaned and made as good as by soaking for a short time in sulphuric acid and w The solution should be weak—about 1 ounce of aci 2 quarts of water—and after soaking a few hours should be washed thoroughly in a strong soda tion, brushed off clean, and dried by heat and then d.

n plugging old holes with bolts or pipe plugs there is n great difficulty in getting them to hold tightly not leak. This is often the case in holes tapped in er jackets where the metal around the hole has rusted y until so thin that it will not hold the thread. Such s may be covered by brazing on a piece of metal y fastening a patch of metal over the hole by means everal small screws and a packing between the jacket the patch. The former requires a professional zer, while the latter takes considerable time, and if jacket is rusted badly you may find several holes lug instead of one covered up. A very good method er such conditions is to file the hole oblong or oval, hown in Fig. 142, *A*. Then cut a piece of stiff brass or steel or iron just large enough to slip into the hole . 142, *B*). Bore a hole through the centre of this e and fasten it on the end of a short bolt or screw threading and rivetting (Fig. 142, *C*). Thread the or screw on the other end almost to the piece of al. Slip the metal piece into the hole and turn nd so that the long ends are across the short diam- of the hole. Put a piece of packing over the pro- ing bolt (Fig. 142, *D*), place an iron or brass patch the packing (Fig. 142, *E*), and screw the whole n firmly against the outside of the jacket by a nut the threaded bolt as illustrated in Fig. 142, and it be found a most satisfactory way to stop up old s or leaks in many places. If the cylinder is a small one the inner piece of metal, or yoke, as well as the patch, must be bent or filed to a curve to fit the jı but in large cylinders the curve is so slight that the outer patch need be curved. The only dan using this method lies in setting up the nut too and thus cracking or breaking the metal aroun hole.

Small cracks or leaks in cylinders or jackets often be stopped by filling with a strong soluti

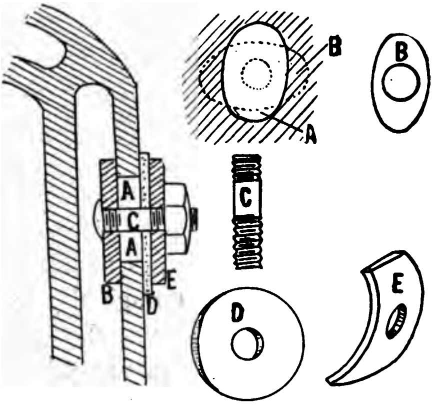


Fig. 142.—Repairing Leak in Jacket

sal ammoniac and water until well rusted up. Ir holes or leaks a better method is to fill the oı with a cement of some sort. Various cements are to withstand heat, water, and oil in iron or meta either of the following will prove excellent and ma be used to advantage in fitting pipe-joints wł permanent connection is desired or in placing a patch as described above or for fastening a plug in a hole.

For Iron

Sal ammoniac	4 parts
Sulphur	2 "
Iron filings	32 "

Mix to a paste with water.

For Iron or Other Metals

Dry white lead	6 parts
Sulphur flowers	6 "
Powdered borax	1 part

Mix to a thin paste with strong sulphuric acid and use at once.

For General Use Where Heat is not too Great

Red lead	5 parts
Litharge	5 "

Mix to a stiff putty with glycerine.

For General Use

Graphite	10 parts
Whiting	3 "
Litharge	3 "

Mix to a paste with boiled linseed-oil.

Small leaks, as well as compression leaks in crank cases, around bearings or in cylinder heads, may be stopped by cleaning the parts and coating with shellac. After the first coat is thoroughly dry a second or even a third coat should be given. Paint or putty should never be used to stop leaks in a motor, but white or red lead will often serve on water-pipe connections. A leak in a water-pipe may also be stopped by winding with adhesive rubber tape, and even a grease-soaked cloth or rag may be used for this purpose with good success in case of emergency. One of the best methods of stopping a leak in a radiator, tank, water-jacket, or pipe is to use chewing-gum. Place a piece of well-masticated gum over the leak and wrap well with adhesive rubber tape or strips of cloth. This will make a perfectly tight repair and will last a long time. I have seen a hole an inch in diameter patched in this way stand daily use for over two years and then, even though the tank had rusted out and had been discarded, the chewing-gum patch was still tight and firm. If small leaks occur in the pipes or radiator they may be temporarily stopped by sprinkling fine cornmeal or bran in the water. This should be done *while the engine is running* or trouble will result. The meal or bran finds its way to every crack and cranny in the system, and where there is a leak it clogs the latter and swells tight. If the meal is placed in the water when the motor is idle it will form masses in the joints and curves and cause complete stoppage of the circulation. One of the worst cases of overheating I ever saw was caused in this way. The meal or bran should be scattered in the water slowly and gradually, and very little used; generally a couple of large spoonfuls is enough.

Sometimes a bearing will become worn or cut and lose compression when it is impossible to get new ones without laying up the motor for some time. Bearings that are loose may often be tightened up by means of a set-screw placed in the bearing box as shown in Fig. 143. With bearings made in cylindrical form this of course cannot be done, but with split bearings it often works very well.

Occasionally you may have some soldered joint come apart or work loose when no soldering appliances are available. It will be very difficult to resolder such a joint unless a gasolene torch is at hand, but if you are in an automobile and have gas or acetylene headlights the joint may be readily sweated or brazed together in the intensely hot flame of these lamps. It is always advisable, however, to be provided with some one of the various prepared soldering compounds which may be used with a common match or oil lamp, or even with a candle.

One of the commonest troubles with four-cycle engines is leakage around the exhaust valve. As soon as the valve becomes pitted or worn it must be reground, for otherwise the hot gases will rapidly cut and burn away the valve until the motor is powerless. It is very easy to grind in a valve, and yet many owners and operators never attempt to do it but go to a repair shop or garage and pay to have it done, and very often poorly or improperly done at that. To grind in a valve the spring and foot must be first removed. This is often very easily done by hand, but in some cases it will be found difficult to get out the cotter holding the foot in place without holding the spring up by mechanical means. Various valve-lifting devices may be purchased for doing this, but a home-made affair as shown in Fig. 144 will answer every purpose. After the spring and foot are removed lift out the valve from its seat and clean the surface of valve and seat thoroughly. If the valve chamber is

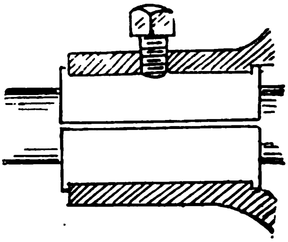


Fig. 143.—Set-screw to Tighten Bearing

readily removed from the cylinder it is best to do so; but if not, the cylinder should be thoroughly plugged with rags or cotton waste. Now spread a thin layer of fine emery and cylinder oil on the surface of the valve and place in its seat. With a screw-driver inserted in the slot on top of the valve, press the valve firmly down and while exerting a steady pressure turn it rapidly back and forth on its seat. Lift the valve occasionally and turn it to a new position and continue rotating. After a few minutes you will find the grinding or "gritty" feel of the valve has disappeared and that it moves about more smoothly and quietly. Now remove the valve and wipe off all the emery and oil on the valve face and seat. If a clean bright surface shows all around, the valve is sufficiently ground, but if spots or streaks of dull or

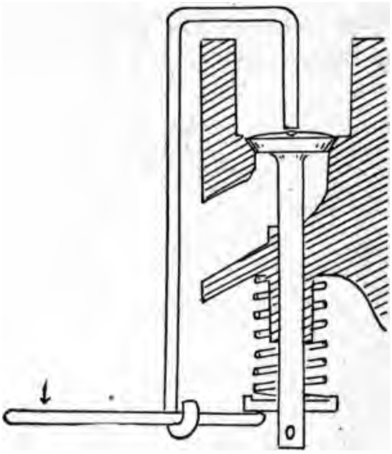


Fig. 144.—Valve-lifter

black metal show here and there the operation should be repeated until the entire surface is smooth and bright.

In grinding be careful not to press down too hard or to get dirt or filings mixed with the grinding mixture, or the valve will be ruined. After the grinding is complete the seat, valve, surfaces around the valve seat, and all other parts where emery may have lodged should be carefully wiped and cleaned, for a minute quantity of emery getting into the cylinder will soon ruin it or a little left under the valve will soon cut it worse than before. Some valves are not provided with a slot in the top for a crew-driver, and in such cases there are generally two mall, round holes. With valves of this sort you should use either a regular tool made for the purpose or should make a tool from an old auger as shown in Fig. 145. After the valve is ground and in place you should examne the stem to see that it does not project so far that it always touches the tappet or push-rod when the latter s in the position for the valve being closed. If the grindng has allowed the valve to drop down until this occurs,

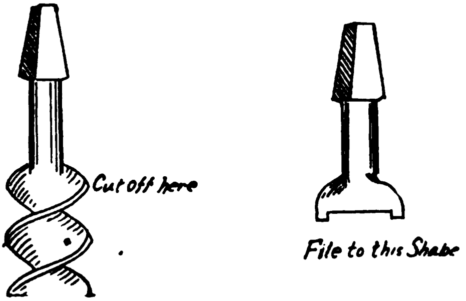


Fig. 145.—Valve-grinding Tool

the tappet or rod should be filed off until about 1/32 of an inch is left between the end of the valve stem and the push-rod or tappet. Never file off the end of the valve stem, as in this case a new valve will prove too long when placed in the old seat. New valves should always be ground into the seats, and a newly ground valve will never be quite tight until it has been operated for some time.

Emery and oil is an excellent grinding compound, but Tripoli, rotten-stone, or very fine pumice will give a smoother and more beautiful finish, although the grinding will take longer with these materials than with emery. Various valve-grinding compounds are on the market; and some of these that are composed of carborundum, and come in the form of a paste in collapsible tubes, are the finest and handiest of preparations for grinding valves. Being in a tight tube and already mixed, there is no danger of foreign matter or grit getting in and the consistency of the compound always remains the same. A tube of this material should be in the kit of every user of a four-cycle motor.

Even when the valves are well ground in and perfectly adjusted a motor will sometimes lose compression and yet it will be next to impossible to discover the joint or crack where the trouble occurs. At such times the leak may be readily located by squirting soapsuds around each joint while the motor is running. Wherever a leak occurs the suds will form bubbles and you will often be surprised to find how many unsuspected leaks there are in your motor when you test it by this method.

A great deal of valve trouble may be avoided by ı small ball race or thrust between the spring 'e foot as shown in Fig. 146. When this is done ɛ revolves slightly each time it seats, and is thus lly resting on a new spot, causing less wear and to cut or pit.

ιt many compression leaks may be traced to the or relief cocks. These cocks exceedingly hot through their onnection with the interior of g chamber and are therefore to very severe conditions. In) be gas-tight they are pro- ith a stiff spring to hold the ʳalve in position, and the heat ly destroys the temper of this nd allows the valve to shake)il and gasolene also tend to the cock and prevent it gas-tight, and often the cock will leak con- ʳ without visible evidence. A cock manu- by the Morgan Mfg. Co. of Newport, R. I., gned to overcome the many difficulties of spring :ocks, is illustrated in Fig. 147. This is a dis- vance in this line of accessories and is a good on of how little things can be improved to add :o the efficiency and service of a motor.

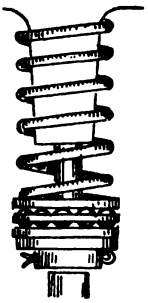


Fig. 146.—Valve with Ball-race

motor troubles are caused by an accumulation and carbon in the cylinders, firing chamber, ambers, or one of the spark plugs or sparking :s. The quickest method of removing such is by using one of the various carbon-removers on the market. Care should be taken in using these to see that none of the compound is left in the motor or the crank case, as they will injure the engine unless thoroughly removed and the parts well oiled afterward. Only light deposits and gummed oil can be thoroughly removed in this way, and for such accumulations plain kerosene oil will work almost as well and is safer and cheaper. Where the deposits have become thick and hard they must be removed by scraping and to do this the cylinder head and other parts must be removed. To thoroughly clean the carbon deposits from a neglected motor is a disagreeable, dirty, and tiresome job; but with decent care and attention there is no need of ever being obliged to do it. Good oil, and not too much of it, will prevent carbon from forming; and if once in a while the cylinders are wiped out with kerosene, and the spark plugs and valves cleaned, there will be no danger of being troubled with carbon and soot.

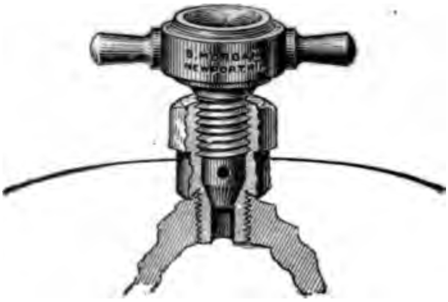


Fig. 147.—"Morgan" Priming-cup

In removing piston rings great care should be used, as hese are very brittle and break easily. By spreading he rings slightly with a pair of pliers, as shown in ig. 148, and then inserting strips of thin tin or brass neath them, they will slip off easily (Fig. 149); new igs should be put on in the same way. The last or vest ring should be taken off first and the others in

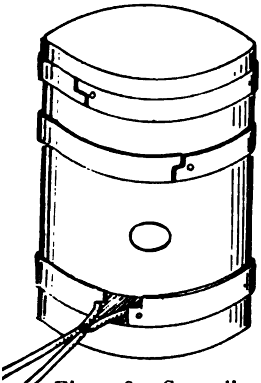


Fig. 148.—Spreading Rings with Pliers

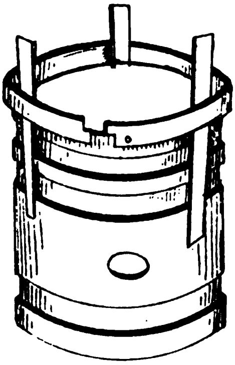


Fig. 149.—Shims for Removing Rings

gular order, and in replacing them the reverse order iould be followed, as otherwise the rings will slip into ie empty grooves and cause lots of trouble.

Special pliers should be used for spreading the rings, s they must work in exactly the opposite manner from rdinary pliers; that is, the nose should open instead f shut when the handles are brought together. Such liers may be purchased ready-made, but are easily onstructed from pieces of steel rod bound together ith wire for a joint as shown in Fig. 150. Oftentimes ings will fail to hold compression when they are not

that there is no leakage past thei
or discolored spots show it indicates

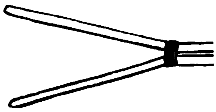


Fig. 150.—Pliers for Spread

with separate heads, where the pistoı
the top, it is often very difficult tc
and rings. By placing bolts or screı
of the cylinder and pushing woodı
these and the rings, the piston maỵ
(Fig. 151, *W*). Strips of brass or ti
as shown in Fig. 152, *S*, *S*, and wi
broken rings.

Most engines have considerable
about them, and it adds greatly to thı

quick and brilliant finish, but the surface of the metal will corrode all the faster afterward and will soon become eaten and pitted until ruined. It is far safer and better to make your own polish and it will cost far less in the end. For rough work, where old corroded brass is to be cleaned, cylinder oil and the finest pumice stone may be used, but for ordinary work or on brass that is in good condition a mixture of rotten-stone and oil, crocus powder and oil, jeweler's rouge and oil, or oil and whiting should be used. If a more liquid polish is desired, a little kerosene may be added until the desired consistency is obtained, while a paste may be made by adding hot paraffine or tallow until the mass partly solidifies when cold. After polishing with any of the above a highly finished result will be obtained by wiping with kerosene and rubbing with precipitated chalk.

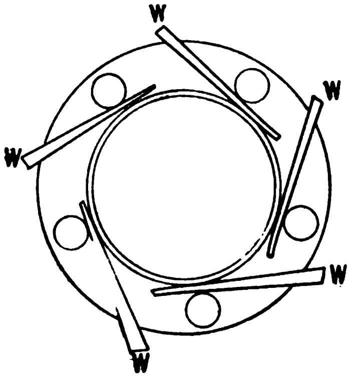


Fig. 151.—Wedges for Putting in Piston

Steel or iron that has become rusty but should have a bright finish may be polished by scouring with emery and oil or emery paper, and afterwards finishing with pumice and oil or rotten-stone and oil. It is better, however, to finish all iron and steel with paint or enamel. Any good engine enamel will answer for most places, but on the exhaust and cylinders a special enamel should be used. For cylinders the highest-grade engine enamel should be used or an enamel made by mixing the color desired with the best quality Japan varnish.

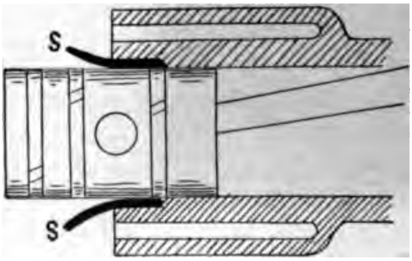


Fig 152.—Shims for Inserting Piston

On exhaust pipes and mufflers few paints or enamels will stand, but graphite mixed with linseed-oil will last longer than any other compound. Before applying paint or enamel to any part of a motor the portion to be painted must be thoroughly cleaned from grease or oil and smoothed bright and clean with emery paper. Old paint or enamel should be smoothed off with emery paper, and if any looseness or cracks appear the old paint should be burned and chipped off to the iron. Parts that rub or bear together, or bearings, should not be painted; many troubles have been caused by painting springs, valve stems, carburetors, igniters, and wires.

Where belts are used there will often be trouble with ɜir slipping, especially where the drive is short. ound water, or in boats, leather belts should be oided. For pump drives, etc., wire-coil belting or rockets and chains are better than anything else, but en wire belts will at times slip on the pulley wheels. hen this occurs wrap two or three turns of adhesive pe around the wheel in the groove, being careful to ve the tape wound in the direction of drive so it will t work up. Cotton-web belts are better than leather most cases, and rubber is also excellent; while for ry long drives nothing excels good manila rope spliced gether. When belts slip they should be treated with me compound or belt-dressing. Many excellent dressgs are on the market, but I have found that resin solved in gasolene and sprinkled on the belt is the st thing in an emergency. This should not be used ely on leather belts, however, for the gasolene soon ns the leather. Perhaps the best material for making elt stick and pull is common tar soap. By holding a e of this against a moving belt it can be evenly disputed and the belt will at once cease slipping.

n winter time some provision should be made for venting water from freezing in the tanks, pipes, iator, and jacket of stationary and vehicle motors. marine engines the water may be drained off to prent this trouble, but in automobiles and stationary gines it is better to add some substance to the water. ycerine, calcium chloride, salt, and various other subnces are used, but these are all more or less injurious metals or rubber pipe. The best material is denatured

up to its proper percentage by
from time to time. When all da
the water should be thoroughly
water put in its place. I have
10-per-cent solution of alcohol (1
water) is safe, and it is very seldom
goes low enough to endanger a mi
tion. If alcohol cannot be procure
parts of glycerine and water, or a
of calcium chloride to a gallon of
fectly safe. A solution that is said
and will withstand a temperature
zero is made by combining 75 pa
potash with 50 parts of glycerine
weight) of water.

Trouble	**Cause**	**Remedy**
Air lock, circulation poor, and motor heats.	Air in water-pipes; pump broken or stuck; leak in intake water-pipe; slip of belt drive to pump. Dirt in check valves.	Mend leaks, or if air-lock, prime pump or pour water through pipes. Open and clean check valves and force water back through intake pipe.
Back or premature explosion; pre-ignition; knocking when running. When starting, motor reverses.	Timer advanced too far. Motor overheated. Too much oil, causing carbon deposit in cylinder. Spark plug rusty or dirty, thus allowing the points to become red hot. Short circuit in timer.	Retard spark. Look after water circulation. Clean cylinder from carbon and feed less oil. Remove and clean spark plug or replace with new one. Clean insulation and wires at timer, or replace.
Batteries exhausted. Sluggish action of motor. Misfires. Engine stops and after standing a short time starts easily but again misses and stops.	Batteries old or wet. Two batteries in contact, thus short-circuiting. Wires or connections loose or broken. Spark-plug points broken, dirty, too far apart, or too close together. Vibrator worn or pitted or irregular in action. Make-and-break igniter out of adjustment or interior electrodes worn or dirty. Rocker	Test batteries. Replace with new ones. Place strips of wood or card between cells. Replace wires and tighten up all terminal connections. Look for broken, worn, or water- or grease-soaked insulation. If fastened with staples remove them. Put in new plug or clean and adjust old one. Test, clean, and adjust the vibrator.

Trouble	Cause	Remedy
	spindle stuck or broken. Springs too weak or broken.	If make-and-break igniter, work spindles by hand and clean with kerosene. Clean interior electrode and mica packing. Place new springs on igniter.
Bearings squeak, pound, jar, shake, rattle, or heat.	Bearings too loose, too tight, dirty, wet, worn, or lacking oil.	Loosen up or tighten bearings as required. Clean with kerosene and lubricate thoroughly. If babbitt is cut, worn, or melted out, it must be replaced.
Blow-back. Popping noises in carburetor or intake pipe. Explosion in the carburetor or flames.	Worn or pitted inlet valve or check valve in carburetor weak. Dirt in inlet valve or check valve stuck. Poor mixture or timing.	Regrind valve. Renew springs. Clean valves. Clean inlet-valve stem with kerosene. Readjust carburetor and timer.
Carburetor. Sluggish operation, irregular running, runs well at slow speed and badly at high, or *vice versa.* Carburetor floods or backfires.	Gasolene supply low, pipes choked with dirt or air, water in gasolene, filter choked; needle valve bent, worn, or dirty; float broken, loose, or water-soaked. Float valve stuck, dirty, or bent. Air-intake choked, loose, or spring broken. Poor or stale gasolene. [illegible] poor	Try flow of fuel through pipe from tank. Blow back through pipe until gasolene runs freely. Drain gasolene from bottom of tank and from carburetor into glass and examine for dirt or water. Examine float and float valve. Remove needle valve and flush with clean gasolene. Readjust carburetor.

	too stiff, broken, or stuck. By-pass or inlet valve choked or dirty.	
Coil buzzes weakly or irregularly. Operation uneven. Sparks brightly at vibrator points. Buzz inside coil. Buzzes when timer is not in contact or when switch is off.	Pitting or wear of vibrator contacts. Wrong adjustment. Batteries weak or short-circuited. Vibrator spring too weak or too stiff. Coil burnt out or wet. Insulation worn out or broken. Short-circuit in coil or timer. Timer worn.	Clean contacts and smooth with fine file. Try various adjustments of vibrator. Test coil and batteries for amperage. Try new spring on vibrator or try motor with new coil. Overhaul all wires and connections. Clean and examine timer.
Compression poor or leaky. Engine loses power and shows little resistance on the compression stroke when turned by hand. Sound of escaping gas when turned slowly. Hard to start. Misfires. Overheating of base.	Valves pitted, worn, dirty, or stems stuck. Valve springs too weak. Cracks in cylinder or combustion-chamber walls. Poor packing at cylinder head or base joints. Rings worn, broken, with lap-joints in line, or stuck in grooves. Broken or cracked spark plug. Compression or priming cup worn, broken, or dirty. In make-and-break motors bearings worn or leak around igniter.	Examine, clean, and, if required, grind valves. Clean and try valve stems. Put on new springs. Squirt oil or soapsuds around various joints and look for bubbles. Place new gaskets in joints. Examine rings and if burnt spots show, replace with new rings. See that rings are pinned in place. Clean grooves for rings in piston. Test priming cup. Try new bearings and test bearings, igniter, and any other joint with soapsuds.

	Cause	
ly fails. 'heel turns mpression	Governor stuck or broken. Valves either broken or stuck. Cam, push-rod, or gears broken or slipped. Valve springs stuck or broken. Cracked or broken cylinder. Broken crank or connecting rod. Badly broken ring or scored cylinder.	Try same located, take thoroughly e
ich resist- ieel, mak- Will run arry load. one direc- nd run a stop.	Not really due to compression. Piston badly worn in one spot, causing it to bear on cylinder. Piston pin or connecting-rod bearings worn so piston cants and jams in cylinder. Bent crankshaft, connecting rod, piston pin, or propeller shaft. Too tight bearings or stuffing box. Red bearings	Detach mot If operation trouble is in Clean cylinde just bearings, bed, and tr motion on be Run kerose and

noises and sudden stoppage.	against each other or one too early and another too late. Reversing too suddenly. Spark too far advanced. Mixture wrong. Broken ring, piston, bearing, connecting rod, shaft, crank, or melted or burned-out crank bearings. Piston seizing through lack of oil. Water leak in cylinder through crack or leaky priming cup, or around igniter. Water in base. Faulty packing allowing water to get into cylinder. Packing in joints too thin, allowing piston to strike edges of flanges at base.	retarded spark. Examine valves and test for proper timing of same. Examine bearings, connecting rod, and shaft. Try new rings. Adjust carburetor. Examine inside of cylinder for water. Drain base and lubricate well. Put in thicker packing.
Cylinder pound or knock Loss of power. Misfires. Loss of circulating water. Steam from exhaust.	Crack in cylinder or water jacket. Leak around packing in head or jacket. Porous iron in casting. Blow-holes in casting. Leak around pipes or cocks in cylinder. Scoring of cylinder.	Proceed as in last and try each part until trouble is located. First try thorough lubricating and cleaning. If a sonoscope is at hand try to locate pound with this. A loose fly-wheel will cause an engine to

Trouble	Cause	Remedy
	Broken rings. Loose piston pin or connecting-rod bearings. Badly worn cylinder. Loose piece of metal in cylinder. Loose flywheel. Loose gears. Broken igniter. Loose bearings. Carbon deposit. Poor water circulation. Pump gland striking eccentric rod or plunger. Poor lubrication. Loose or worn eccentric straps.	pound badly and will be hard to locate. Tighten up nut on same and use a new key.
Flare-up. Flame at the carburetor or around intake manifold. Back explosions.	Leak in pipe line or connections and short circuit, causing spark that ignites same. Poor or weak mixture. Gasolene in base. Valve or check stuck or in bad shape, thus allowing burning gas to blow back and ignite gasolene in carburetor. Leak around the manifold or intake-pipe flange connections.	Very dangerous and should be attended to immediately. Easy to locate and remedy.
Gear seizes; refuses to hold, slips, or grates and groans.	Worn or loose gears. Water or dirt in gears. Gear-case loose or dirty. Poor lubrication. Wrong	Overhaul gear, clean, lubricate, and adjust. If any loose, worn, or broken parts, they should be

Trouble	**Cause**	[illegible]
	piece in gear case. *Broken ball in* thrust bearing. Gear out of line with engine.	
Governor fails to work. Engine races, cuts out too soon, or stops. No compression. Runs first fast, then slow. Suddenly speeds up or slows down. Picks up badly under load.	Springs too strong or too weak or broken. Arms of weights stuck or bent. Toggles, or sliding collar, stuck or jammed. Loose parts causing backlash. Mechanism out of true or badly adjusted: Springs rusty or parts gummed from old oil or paint.	Clean thoroughly and oil well. Look after springs and see that all parts move readily and freely but are not loose.
Ignition bad. Engine runs sluggishly and unevenly. Sometimes runs jerkily. Will start on priming charge but not run itself. Misfires. Back explosions. Muffler explosions. Pound.	Short circuits; weak batteries. Coil burnt out or vibrator stuck. Short circuit in coil of timer. Engine timed so that ignition takes place too late or too early. Timer contacts worn. Wires broken or insulation bad. Magneto broken, short-circuited, or belt slips. Brushes worn or dirty. Oil or water on spark-plug points. Igniter points worn or dirty. Mica packing broken or oil-filled. Igniter springs too weak or rocker	Overhaul wires and test batteries and coil. Clean vibrator. Try a new coil. Clean contacts and all connections on switch, coil, and plug. Clean plug or use new one. Clean timer and oil it well. Try on batteries without magneto. Replace brushes if worn. Try new springs on igniter. Clean spindle with kerosene. Tighten rocker on spindle. Clean mica packing or replace. If wires are wet or oil-soaked try new wire. Remember

Trouble	Cause	Remedy
	spindle stuck, bent, or rocker loose on spindle.	that most motor troubles are in the ignition.
Knocking or pounding. Any unusual sound or rattle in cylinder base or about any part of engine. Occasional loud explosions when starting or smoke blowing out from joints in crank case in two-cycle motors.	Pre-ignition. Spark too far advanced. Soot or carbon in cylinder or plug. Short circuit in timer. Overheated engine. Want of oil. Poor oil. Some part loose, cracked, or broken. Worn or dry bearings. Loose piston pin. Broken rings. Loose weights on governor or parts of governor striking engine. Choked muffler or too small exhaust pipe. Water in cylinder or base. Too weak a mixture.	Retard spark. Clean plug and cylinder. Look at rings. Test all parts for looseness. Watch timer for sparks in same.. Test for short circuits. Thoroughly oil all parts. Examine for water. Try with muffler disconnected. Give richer mixture.
Loss of power, or poor speed. Sluggish running. Misfires. Back explosions. Smoke from base of engine and carburetor. Black smoke from exhaust. Blue smoke from exhaust. Failure to run even when motor starts easily.	Faulty ignition. Poor mixture. Faulty lubrication. Too much air in mixture causes base explosions. Too much gasolene causes misfires and black smoke. Too much oil causes blue smoke. Failure to turn over more than once or twice when started shows too rich mixture or some stoppage in gasolene supply, inlet valve stuck, or base	Overhaul ignition. Give more or less fuel as required. Give more or less oil. Drain and clean carburetor, pipes, and tank. Try new spring in check valve. Work the inlet valve by hand and clean with kerosene. Use a heavier grade of oil on bearings.

	Cause	**Remedy**
	compression leaky in two-cycle engines. Also caused by failure of check valve to seat properly in two-port engines.	
Lubrication poor or intermittent. Overheating. Sluggish running. Bad smells from exhausts. Misfires. Blue smoke. Knocking, pounding, or seizing of piston or bearings. Noise. Warm or hot bearings.	Poor oil or oil of an improper consistency. Forgetting to oil or failure to feed oil regularly. Oil-feeds choked with old oil, dirt, or water. Oil-pump (in force feed) out of order; belt or friction drive to oiler slips. Particles of grit or metal in oil. Leak in oiler tank.	Try a different grade of oil and thoroughly clean all oilers, pipes and feeds, and oil connections. Adjust feeds accurately to feed more or less as required. Try new belt or friction wheel. Test tank for leakage. Use the best oil money can buy; oil is cheaper than engines.
Misfires. Engine runs sluggishly or jerkily. Runs well a short time and then slows down and stops. Explosions in base or muffler.	Ignition or carburetor troubles. Dirty plugs, connections, or switch contacts. If engine runs slower and slower and then stops without overheating, batteries are run down. Timer dry, dirty, or worn. Igniter binds in bushing when hot. Muffler chokes up or carburetor does not feed as fast as motor requires. Tank too low or	Overhaul ignition as for troubles already described. Try new switch, wires, or timer. Keep timer well oiled. Use new batteries. See that belt, gear, or friction on magneto drive are not slipping. Try without muffler or with cut-out open. Depress float on carburetor. Give more gasolene or less as required. Raise

Trouble	Cause	Remedy
	no air-vent. Dirt or water in pipes. Float set too low. Needle valve or throttle shakes shut.	tank. See that air-vent is free. Tighten lock nuts on valve or throttle.
Muffler troubles. Loud explosions, noises, rattle. Hissing.	Unexploded gas entering muffler and exploding by heat of same or by burning gas from next exhausted charge. Muffler choked or too rich a mixture used. Misfires. Poor ignition or leaky valves.	Slow motor down before stopping. Shut off by throttle before using switch. Use water-cooled exhaust or muffler. Clean muffler. Tighten up all muffler and exhaust connections and bolts. Use weaker mixture.
Noises and rattle around engine.	Loose nuts or bolts. Loose connections. Worn valves or push rods. Poor springs or loose small parts. Some part bent, cracked, or out of adjustment. Common trouble on make-and-break motors.	Tighten up all connections, screws, and nuts. Hold piece of wood, or hand, on various parts to determine where noise originates. Oil well. Place fibre washers under springs and wherever two pieces of metal hit or rattle against one another. Replace these washers as fast as worn out. Take up all lost motion.
Overheating. Smell of burning oil or paint. Smoke from jacket or cylinder. Boiling from radiator or pump. Pounding. Engine	Defect in water- or air-cooling system. Choked or air-locked pipes. Pump broken, jammed, or stuck. Packing around pump spin-	Renew or clean all pipes, radiator, etc. Examine pump and pump-drive. Examine check valves and clean. Tighten or re-

Trouble	Cause	Remedy
grinds and slows down or stops. Will continue to fire after current is turned off.	dle or plunger on plunger pump loose or leaky, allowing suction of air. Check valves in water-pipe stuck, worn, or dirty. Bits of metal in pump or valves. Racing engine. Spark too much retarded. Not enough lift to exhaust valve. Too much gasolene. Water-jacket choked with dirt or scale. Drive to pump broken or slipping. Poor lubrication. Water intake choked up.	place packing. *Tighten all joints on intake water-pipe.* Force water or air back through outboard inlet on marine motors. Flush water-jacket by forcing water back through it. Use an exhaust valve with longer stem. Adjust mixture and oil feeds. Stop engine at once and allow to cool gradually. Do not throw cold water on it. Oil well and turn over by hand several times before attempting to start it again. Never run a motor when it overheats.
Piston troubles. Piston pounds, seizes, or is too loose. Engine stops or is very hard to turn over.	Poor lubrication. Piston rings stuck in grooves. Broken or worn rings. Cylinder scored from using broken rings. Gummy or poor oil. Overheating. Grit or rust in cylinder. Connecting rod or piston-pin bearings worn out of true, allowing piston to cant to one side and jam. Connecting rod bent.	Pour kerosene through head of cylinder and turn engine over a number of times. Oil well and drain all kerosene from base. Examine rings and piston. Clean grooves and replace rings or use new ones. If cylinder is scored replace or have rebored. Examine connecting rod, piston pin, and bearings. Clean out all carbon

	Cause	
		and rust. I have it gro grade machi
or. Flame tor. Flood- rburetor.	Too rich or too weak a mixture. Inlet valve stuck or worn or spring too weak. Spark too much retarded. Float in carburetor stuck, broken, or wrongly adjusted. Float valve loose, worn, or dirty.	Adjust m retor. Exa spring. Ad Clean float a in new ones.
res. Slug- Sparks on imer or at suddenly.	Loose, dirty, worn, wet, or grease-soaked wires. Broken insulation. Poor terminal or switch connections or contacts. Batteries or wires touching. Worn-out or wet coil or	Go over ev tion, test pl new wires, Never use m over wire.

Trouble	Cause	Remedy
Spark-plug troubles. Short circuits. Misfires. Leakage around plug.	Unsuitable plug. Plug too short or too long. Wet or moist plugs. Water, rust, or carbon on points. Core cracked or loose. Electrode nearly broken or burnt through. Points touching or too far apart. Porcelain or mica core broken or sooted. Terminal for wire loose. Packing blown out or broken, allowing leak of compression. One or both points broken. Rust or oil between thread of plug and plug hole in engine.	Clean and overhaul plug. Use a plug long enough to reach well into cylinder but not so long that it will strike piston or valves. Have thread in cylinder clean. See that wire connection is clean and tight. If points are badly worn or burnt use a new plug. If points are rusty, corroded, or sooty, smooth with fine emery cloth. Always have several plugs on hand and as soon as trouble is traced to plug replace with a new one; the old one may be repaired at any time.
Timer troubles. Knocking or pounding. Loss of power. Overheating. Irregular firing. Explosions in muffler or intake.	Badly worn timer or fibre insulation. Weak timer springs. Timer dry and stuck. Incorrect timing. Timer loose on shaft. Timer control rods bent, loose, or out of adjustment. Badly worn crank shaft, cam, cam shaft, gears, push-rod, or any valve trouble. Poor mixture which ignites slowly.	Clean and oil timer. Take up lost motion and, if necessary, try a new timer. Adjust so that contact is made just after end of compression stroke when spark is retarded. Look over rods, gears, shafts, etc. Replace any weak or worn springs and any old, worn fibre.

Trouble	Cause	Remedy
	Cam-shaft gear badly set, worn, or a tooth chipped or broken.	
Valves. Slow action. Loss of compression. Misfires. Sluggish running. Noisy exhaust. Light knocking.	Sooty or gummy deposits on stems or springs. Spindles bent, broken, or rough. Spring too strong or too weak. Pitted or scored valves. Wear of cam, gear, push-rods, tappets, valve stems or feet, or a cotter-pin in same which is loose, worn, or broken. Also hole for cotter-pin being worn oval or oblong. Not enough or too much lift. In case of automatic inlet valve, leak in cylinder or by piston, thus preventing suction from opening valve.	Clean valve stems by free use of kerosene while operating same by hand. If pitted, worn, or scored, the valve should be ground. If stem is bent get a new valve. New springs are a great help. New pins and feet, if old are worn, will make a great improvement. **See that all lost motion is taken up but that the push rod or tappet is *not* continually bearing against the valve stem. Test your valves now and then to see that they are properly timed; the variation of 1/32 of an inch in the piston travel as compared with valve opening or closing will add or detract a lot of power from the motor.**
Water in crank chamber. Water in carburetor. Loud explosions. Steam from exhaust. Slow or ir-	Leaky joints in jacket, at head, or other packed joints; around pet-cocks or priming cups. Water	**Provide a strainer in pipe line. Protect tank and carburetor from rain. Draw off a small lot of gaso-**

waves, spray, or rain. It often condenses on inside of tank or base or in carburetor in damp or foggy weather. When motor is running evaporation of gasolene causes intense cold on carburetor and the moisture thus accumulated may be drawn into cylinder.	lene from carburetor before starting motor. Drain base of engine thoroughly. Examine cylinder for leaks by filling jacket with water and looking inside while cylinder head is removed. Put new gaskets and packings on all joints. Wipe off carburetor when running if water collects.

CHAPTER IX

GLOSSARY OF ALPHABETICALLY ARRANGED TECHNICAL TERMS USED IN CONNECTION WITH GASOLENE ENGINES, WITH EXPLANATIONS.—VARIOUS USEFUL TABLES; HEAT VALUE OF FUELS; SIZE AND CAPACITY OF TANKS; IRON-PIPE SIZES; DRILL SIZES FOR SCREW HOLES; UNITED STATES STANDARD SCREW THREADS; CAP-SCREW SIZES; FINDING SURFACE AND VOLUME.

GLOSSARY OF TECHNICAL TERMS

Accelerator—Any attachment or device for increasing speed.

Advanced Spark—An electrical spark produced to ignite a charge of gas in a motor before the piston reaches the upward limit of its compression stroke.

Air Lock—A gathering of air in a pipe which prevents the flow of liquid through the same.

Annular—Pertaining to or in the form of a ring.

Annular Bearing—A bearing in the form of a ring.

Annular Opening—A ring-shaped opening.

Ampere—A unit of electrical measurement nearly analogous to quantity.

Ampmeter (*Ammeter*)—An instrument for indicating or measuring amperes.

Armature—A wire coil around an iron core used in producing electricity between two magnets, as in a dynamo.

Atmosphere—The weight, or pressure, of air, equivalent to 15 pounds per square inch.

Babbitt—A composition of various soft metals used as bearings to overcome friction. Bearings made from babbitt.

Backfiring—The backward or premature explosion of a gas engine.

Baffle Plate—A plate or partition to turn or stop the flow or force of gases or other matter.

Balance Weight—A weight attached to a crank, shaft, or wheel, to balance the explosive force of the motor and lessen vibration, as well as to overcome the tendency to a dead centre.

Ball Bearing—A bearing in which revolving steel balls aid in overcoming friction.

Ball Cage—A metal cup, ring, or recess, holding the balls in a ball bearing.

Ball Check—A check valve in which a ball fits over the opening, in place of a regular valve.

Ball Pein—The round end of a machinist's hammer.

Ball Race—Hardened steel washers, or disks, against which the balls bear in a ball bearing.

Bearings—The parts on which a revolving surface rests, or through which it passes in contact.

Bed—The surface to which a motor is fastened by its bed plate.

Bed Plate—The flat surface at the base of a motor used to attach the engine to its bed.

Bell Crank—An angular crank transmitting power, or pull, at right angles.

Bevel Gear—Cog-wheels, or gears, with sloping faces for transmitting power at an angle.

Binding Post—The post, or metal object, to which electrical wires are fastened.

Boxes—The metal casings which contain, or hold, bearings in place.

Brasses—Bearings of bronze or brass used in place of babbitt.

Break Spark—An electrical spark produced by interrupting or breaking an electrical current.

Breaker—An object for breaking or interrupting an electrical current.

Brushes—Metal or carbon points used to gather or transmit electricity from the armature of a magneto to the wires.

Burr—A roughened or enlarged edge, or end, of a bolt, shaft, pipe, or other metal object.

Bushing—A cylindrical shell or casing to reduce a hole in a pipe, wheel, or other object or to enlarge the object that passes through a hole.

Butt Spark—See *Kiss Spark.*

By-pass—The passage through which the explosive gas passes from the base to the firing chamber of a two-cycle motor.

Cam—An irregular or variously shaped piece attached to a shaft and so designed as to transmit a varying motion.

Cam Gear—The gear used to operate a cam.

Cam Shaft—The shaft, or spindle, carrying a cam.

Calorific Power—The power actually contained in a unit of heat.

Calorific Value—The number of thermal, or heat, units contained in a certain quantity of fuel.

Cap Screw—A form of machine screw, or bolt, having a square or hexagonal head.

Carburetor—A device for so combining or mixing liquid fuel with air as to produce an explosive or combustible gas.

Castellated Nut—A nut with grooves on its top, to hold cotter pins.

Catalytic Ignition—Ignition by the use of spongy platinum which becomes incandescent in contact with coal-gas or carbureted air.

Centrifugal Governor—A device which regulates the speed of an engine by the centrifugal force of weights operating through springs or other devices.

Centrifugal Pump—A pump which operates by a revolving fan or wheel within a casing, and which forces water or other liquids by centrifugal force.

Check Valve—A valve so constructed that the valve lifts or opens to the pressure in one direction, but closes or seats when pressure is exerted in the opposite direction.

Choking—The failure of a motor to operate properly through the surplus of oil, fuel, carbon, or restricted passages in the exhaust.

Clearance—The space between the top of piston at its upward limit and the interior of the top of the cylinder; space between any two objects.

Clutch—A device for holding motion or power between the motor and the mechanism to be operated and which may be thrown off or released at will.

Coil—Wire wound about an iron core used to create a greater intensity in the electrical current.

Columbia Locknut—A form of nut provided with a tapered, threaded bushing within a nut; so designed as to contract or grip the thread upon which it is screwed and thus obviate slipping or working loose.

Combustion Chamber—The chamber or space in the cylinder, or connected thereto, in which the gas is ignited or exploded.

Commutator—A revolving or oscillating object connected to the wires of an armature and through the action of which the electricity is transferred by brushes to the wires. Also applied to timers.

Compression Stroke—The stroke of a piston which compresses the gas in the cylinder and at or near the limit of which the ignition and explosion take place.

Compression Cock—Same as *Relief Cock.*

Condenser—Numerous sheets of tin-foil placed in an induction coil and connected to wires across the interrupter. Designed to reduce primary sparking at the contacts and to increase the current.

Connecting Rod—The arm or rod connecting the piston with the crank shaft.

Constant Oil Feed—A device for constantly feeding oil while the machine is in operation. A force-feed oiler.

Contact Points—The points through which an electrical contact is made. The platinum points of the vibrator or of the electrodes on a make-and-break igniter.

Controller—A device for controlling any mechanism.

Cotter Pin—A metal pin with the two ends bent around so as to lie close together. When placed in a hole the ends are separated, thus preventing the cotter from slipping out.

Counterweight—The same as *Balance Weight.*

Counterbalance—The same as above.

Coupling—Any device for connecting two pipes, rods, or shafts.

Crank—The offset portion of a shaft to which the connecting rod is attached and through which power is transmitted to the shaft.

Crank (*Starting*)—The crank or handle for turning over or starting the fly-wheel of the motor.

Cranking—The operation of turning over the fly-wheel of the motor by hand to start the engine.

Crank Case—The case or recess within which the crank revolves.

Crank Shaft—The shaft bearing the crank.

Cross-head—The piece to which the connecting rod is attached and to which the piston rod is also fastened, and which slides in guides, thus transmitting straight linear motion to a crank by allowing the connecting rod to oscillate on a pivot through the cross-head.

Current-breaker—A device for interrupting or breaking the current of electricity to produce a spark.

Cut-out—A device for allowing the exhaust to pass directly into the air without going through the muffler.

Cylinder—The portion of the motor which contains the piston and within which the explosion takes place.

Cylinder Ribs—Metal ribs, or flanges, cast upon the cylinder's external surface to radiate heat and cool the cylinder in air-cooled motors.

Cycle—A certain period of time within which the same events occur *regularly.* As applied to gas engines it is practically equivalent

to "stroke" and is one-half a revolution of the fly-wheel, approximately.
Cyclic Phases—The phases or changes in operation during each cycle of a motor.

Dead Centre—That portion of a revolution during which the piston cannot transmit motion to the crank; the upward and downward limits of the stroke.
Deflector—The projection from the top of the piston in two-cycle motors designed to prevent the inrushing gas from passing across and mingling with, or escaping with, the exhaust and to direct its course toward the top of the cylinder.
Diaphragm—A thin plate or partition, usually flexible.
Die—A tool for cutting male screw threads on rods or pipes.
Die Stock—The handles and holder for holding a die when using i
Differential Gear—A combination of gears, or wheels, so arrange that motion may be transmitted to different speeds or power or where the resistance is unequal the power exerted may b equalized.
Differential Cam—A cam transmitting varying motions or powers.
Differential Piston—A piston composed of two pistons of differe sizes and operating together to perform separate duties.
Distillate—Denatured alcohol or similar fuels.
Distributor—A device for distributing anything. In connection wi motors it is usually applied to a form of electrical device whic distributes the ignition current to the various cylinders, but also applied to devices for feeding oil or to an arrangement f leading the charges of gas to various cylinders (see Elmore moto
Dog—A mechanical appliance for transmitting certain motions.
Dowell—A pin or key used to hold two pieces or parts together.
Drop Tee—A pipe fitting in the form of a tee but provided with a bracket or flange for fastening to a wall or other object.
Drop Ell—A pipe elbow with bracket as above.
Dynamo—A machine for generating electricity through the revolution of an armature between electro-magnets.
Dynamometer—A device for ascertaining the power necessary to operate a machine at a given speed.

Eccentric—A circular disk set on a revolving shaft with its centre out of true with that of the shaft and used to transmit reciprocating motion from rotary motion.

Eddy Current—A current or irregular flow of the gas caused by square or rough corners in the passages which prevent a free flow to or from the cylinder.

Electro-magnet—A piece of iron covered with a coil of wire. When an electrical current is passed through the coil the iron core becomes highly magnetic.

Electrodes—The two points carrying the electric current between which a spark is produced, as in a spark plug.

Exhaust—The escape of the burnt gases from the cylinder. The opening through which these gases escape.

Exhaust Valve—The valve which allows the burnt gases to escape from the cylinder.

Expansion Joint—A joint or coupling so designed as to be capable of expansion and contraction by one side sliding over the other.

Face—The smooth or flat surface of a joint or wheel.

Face Plate—A plate of metal provided with clamps by the use of which an object is held in a lathe where the surface is to be turned off or faced.

Faced Joint—A joint made by having the two surfaces ground smooth and flat.

Fan—A revolving wheel or disk provided with blades or paddles for circulating air about a motor to cool it. Applied erroneously to a propeller wheel.

Feather Vibrator—A form of vibrator of very delicate construction and capable of very rapid vibration.

Flange—A projecting surface, or ridge, usually applied to parts designed to be bolted together or attached to some other object.

Flange Coupling—A joint formed by fastening two pipes or shafts together by two flanges bolted together.

Flange Union—A flange coupling when applied to pipe.

Flash Point—The temperature at which a substance ignites.

Flexible Coupling—A coupling composed of oscillating parts so designed as to allow the shaft to revolve even when the two parts are at an angle.

Flexible Elbow—An elbow constructed as in the above.

Flexible Joint—Same as above, but more often applied to small rods, etc.

Flexible Union—A union for connecting pipe constructed with parts which permit it to be set at varying angles.

Float Feed—An arrangement by which the flow of a liquid is regulated by a valve operated by a float.

Flooding—An excess of gasolene or other liquid fuel in an engine.

Fly-wheel—The large wheel at the end of the shaft used to carry the momentum of the shaft beyond dead centre and to minimize vibration.

Four-cycle—The operation of a motor in which an explosive impulse occurs only on every other revolution of the fly-wheel or on every fourth stroke.

Friction Clutch—A clutch in which the power or motion is held and transmitted by frictional resistance.

Gap—The space through which a spark will pass between two electrodes or terminals.

Gasket—A ring of material, or packing, placed between two surfaces to render the joint tight.

Gate Valve—A valve which operates by a gate or partition that rises and falls in a groove or guide, thus giving a full opening; a full-way valve.

Gauge—An instrument for measuring anything.

Gear—A cog-wheel. A combination of cog-wheels. A device for transmitting power, speed, or direction through a combination of cog-wheels or "gears."

Gear Pump—A form of rotary pump in which the water is sucked in and forced out by the revolution of two interlocking gears.

Generator—An appliance for generating gas from liquid fuel and air. An instrument for generating electricity.

Gland—A ring, or thimble, of metal used to hold packing in position.

Globe Valve—A valve which operates by a circular or globular valve seating by turning down a threaded stem or spindle.

Governor—A device for regulating power, speed, or flow. In connection with gasolene motors, a device for regulating the speed of the motor within certain limits.

Gravity Feed—The feeding or flowing of oil by gravity alone.

Gravity Oiler—An oiler operated by gravity. Not a force-feed oiler.

Grounding—Connecting one wire from an electrical generator to the ground or to the frame of the motor and using the same in place of a complete wire to the other electric terminal.

Hammer Break—A form of breaker, or interrupter, which acts like a hammer by striking upon another piece of metal.

lammer Vibrator—A vibrator constructed heavily to give stronger and slower vibrations than other forms.

langer Bolt—A lag-screw with a threaded end in place of a square head and onto which a nut may be screwed after the screw itself is in place, thus avoiding removing the screw from the wood in order to remove the object held in place by the screw head.

lelical Gear—A gear wheel with the teeth cut at a certain slant or curve, which forms the part of a helix or coil.

lelical Spring—A spring made in the form of a helix; a coil spring.

ligh Tension—A form of electrical discharge of high amperage. The induced current in an induction coil. The secondary current.

lit-and-miss Governor—A governor which regulates the speed of an engine by allowing the valves to lift or remain closed through the action of an arm or blade which operates at normal speed but which misses when the desired speed is exceeded.

lorse-power—The power required to lift 33,000 pounds one foot in one minute.

lot Tube—A form of ignifer in which the charge of gas is exploded by the use of a tube kept at red heat.

Hunting—The irregular action of a governor causing an engine to slow up or increase its speed at intervals.

Hydrometer—An instrument for testing the specific gravity of liquids.

Igniter—Any device for igniting the explosive charge of gas.

Igniting Device—Same as *Igniter.*

Ignition—The process of igniting the charge of gas.

Ignition Plug—A plug inserted in the cylinder and which carries the electric spark used in igniting the charge; a spark plug.

Indicator—A machine for ascertaining the action of an engine by means of a tracing on a card.

Indicator Card—The card on which an indicator forms a tracing to show the action of a gasolene motor.

Inductance—The power of inducing, or generating, electricity in a coil of wire by passing an electrical current through another coil close to but not in contact with the other.

Induction Coil—A coil for generating induced electricity.

Inertia—The tendency of an object to remain stationary when at rest and which must be overcome before it starts to move.

Inertia Governor—A governor that acts through inertia.

Inlet Valve—The valve which admits the charge of gas to an engine's cylinder.

Insulation—The protection, or covering, of electrical conductors to prevent the escape of electricity.

Insulator—Anything which prevents the electricity from escaping from a conductor.

Intake—The opening through which the fresh gas is taken into the cylinder.

Intake Stroke—The stroke of an engine's piston which draws a charge of gas into the cylinder. The suction stroke.

Jacket—The portion of a motor covering the cylinder and separated from it by a passage for the circulation of water or other cooling liquid.

Jig—A device by which any machined article may be accurately duplicated.

Journal—A bearing on a shaft.

Journal Box—The casing holding a journal.

Jump Gap—The space through which an electric spark will jump.

Jump Spark—A spark of high-tension electricity which is caused by separating the electrodes or terminals of a circuit, thus causing the electricity to leap or jump across, producing a hot spark.

Key—A square piece of metal inserted between a wheel, or similar object, and a shaft and fitting into recesses in each to prevent turning or looseness of the two parts.

Keyway—The slot or recess into which a key fits.

Kicking—Backfiring or premature explosions causing the motor to reverse its motion when starting or to "kick" backwards.

Kiss Spark—A form of make-and-break ignition in which the contact points approach gradually, press firmly together, and separate instantly. Also called Butt Spark.

Lag-screws—Heavy wood screws provided with a square bolt head.

Lead—The advance or timing of a spark to cause ignition before the limit of the compression stroke, causing the explosion to exert its greatest force just as the piston passes dead centre.

Lever—A rod or arm for increasing, transmitting, or controlling power or motion.

Liners—Thin pieces of metal for reducing or enlarging the space between two pieces of metal.

Nut—A nut screwed onto a bolt above the regular nut to event the latter from working loose.

Washer—A washer, or ring, with one side cut through and the ds slightly turned up or sprung apart. Used to place under a it on a bolt. The turned-up edges prevent the nut from loosen- g or working off by the friction of the ends bearing on the under rface of the nut.

Motion—Any looseness or motion which accomplishes no useful rpose and detracts from power or speed.

Tension—The primary electrical current either direct from a nerator or battery or after being passed through a primary- und coil.

icant—Any substance that lubricates or reduces friction be- een moving parts.

icator—Any device for distributing a lubricant.

—A metal projection for attaching to another object or for aring against another piece.

neto—A machine for generating electricity by means of an mature revolving, or oscillating, between two permanent mag- ts.

e and Break—A system of ignition in which the spark is produced alternately making and breaking an electrical current.

ifold—The common outlet of several pipes or tubes.

ometer—A gauge or instrument for determining the pressure of ses.

anical Equivalent.—The power contained in a gaseous body and ich must be accounted for, either as heat abstracted from it or some form of mechanical energy. A deduction from the law at nothing in nature can be lost or wasted.

anical Oiler—An oiler or lubricator operated by mechanical ans.

anical Valve—A valve operated by mechanical means.

ire—The failure of a compressed charge to ignite and ex- ode.

entum—The tendency of an object to continue in motion after e power required to move it has been stopped.

r—Any machine for producing power or for transforming tural forces to mechanical motion.

ler—A device for quieting or silencing the noise of the ex- ust.

Needle Valve—A valve formed by a pointed rod bearing against the circumference of a small hole.

Nipple—A short piece of pipe threaded at both ends.

Offset Cylinder—A cylinder so placed that its centre is at one side of the centre of the crank shaft.

Offset Crank—A crank placed so that its centre is out of line with the centre of the cylinder.

Ohm—A unit of electrical measurement denoting resistance dependent upon diameter, length, and material of the electric conductor. Analogous to "friction."

Oil Feed—A device for distributing oil.

Oil Pump—Any device for pumping oil.

Otto Cycle—Four-cycle. So called because the Otto engine was the first to successfully adopt this system of operation.

Packing—Any material used to prevent leakage around a moving part or between the two surfaces of a joint.

Packing Gland—A piece of metal which presses the packing into place and is held by a threaded screw or other device.

Packing Nut—A nut used to hold packing in place.

Pein—The end of a hammer used for striking.

Peining—Hammering or stretching a piece of metal by use of the "pein."

Pendulum Governor—A governing device in which the speed is regulated by the swing of a pendulum instead of by centrifugal force.

Phases—See *Cyclic Phases.*

Pick Blade—The small blade or pick of metal which lifts the valve in a pick-blade governor.

Pick-blade Governor—A governor that regulates the speed of a motor by means of a blade or pick which lifts or misses the valve stem under excessive speeds.

Pillow Block—A block or stand supporting a bearing or journal.

Pinion—A small cog-wheel. Properly a wheel with pins or posts in place of cogs.

Piston—A sliding object within a cylinder; a plunger.

Piston Pin—The pin which holds the connecting rod to a piston.

Piston Ring—Metal rings fitted loosely around grooves in a piston which by spring of the metal form a gas-tight joint with the cylinder walls.

ian—The same as *Connecting Rod.*

ng—Wearing away or corroding of metal in the form of small les or indentations.

imeter—An instrument for determining the area of indicator agrams.

—In motor parlance, the *Spark Plug.*

ger—A piston. Any object working or sliding within a cavity ade to fit its surface.

ger Pump—A pump operated by means of a plunger or piston.

—An opening through which gas is admitted to the cylinder or se of a motor.

ignition—The igniting or exploding of a charge of gas before the oper time.

ary Coil—A coil for producing low-tension electricity but not duced current.

ary Winding—The first winding on a spark coil conveying the imary or low-tension current.

ary Wire—The wire used to convey the primary or low-tension ctrical current.

ing—Pouring or injecting liquid fuel into a cylinder to start e motor. Placing water in a pump to start its operation.

ing Cup—A cup for priming, usually a small receptacle tached to the cylinder and connected with the interior by a lve or cock.

y Brake—A device for testing the power of gasolene motors.

ractor—An instrument used for determining angles and degrees a circle.

dle Carburetor—A form of carburetor in which the liquid fuel in a pool or puddle instead of in a float chamber, and from the rface of which the gas is drawn.

meter—An instrument for measuring the temperature of exhaust ses.

rant—Any piece of metal in the shape of a quarter circle; ually applied to the curved, notched piece which holds levers in sition.

—A notched, or cogged, bar operating on a cog-wheel for ansmitting rotary motion to reciprocating motion or *vice versa.*

and Pinion—The combination of a rack and a small cog-wheel *pinion.*

Radiator—A device for giving off, or radiating, heat and through which the hot water from the cylinder jacket is passed in order to cool it.

Ratchet Valve—A valve operated by a ratchet gear instead of by cams.

Ratchet Wheel—A disk or wheel with notches or projections so formed that it will turn in one direction but not in the other by dogs or lugs dropping into the notches.

Ratio—The proportion or relation of one thing to another.

Reducer—An appliance for reducing the size of an opening or of a rod or shaft.

Reducing Coupling—A coupling smaller at one end than at the other for reducing the size of any two pipes or rods which are connected by the coupling.

Reducing Elbow—An elbow with one opening smaller than the other.

Relief Cock—A cock or valve placed in the cylinder to relieve the pressure of compression.

Ribbon Vibrator—A vibrator made with a slender or thin piece of metal to which the contact point is attached.

Ring Oiler—A device in the form of a ring which is attached to the crank shaft and serves to distribute the oil in the crank case to the bearings and connecting rod.

Ring Valve—A valve in the form of a ring or cylindrical section.

Rotary Valve—A cylindrical or conical valve which rotates or revolves on its seat instead of lifting and closing.

Ruhmkorff Coil—An induction or vibrator coil.

Scavenging—The cleansing of the cylinder of burnt gases.

Secondary Coil—An induction coil.

Secondary Current—The induced current of an induction coil.

Secondary Wire—Heavily insulated wire for carrying the secondary current.

Self-oiling—Oiling without the aid of mechanical devices.

Self-starting—Equipped with a device for starting without turning or "cranking" the fly-wheel.

Set-screw—A screw of hardened steel or other metal used to hold a shaft or other object in place.

Shaft—Any revolving rod for transmitting power or motion.

Shaft Bearing—The bearing through which a shaft passes.

Shaft Coupling—A coupling for fastening two ends of shafting together.

Shaft Hanger—A bearing for shafting attached to a frame or post for fastening to a wall, floor, or ceiling.

Shims—Thin pieces of metal placed between joints to keep the two parts separated.

Short Circuit—The passage of electricity from one point to another without passing through the conductors provided. The escape of electricity through faulty insulation.

Sight Feed—A device by which the flow of oil or other lubricant may be seen in exactly the amount and condition in which it is fed to the parts to be lubricated.

Silencer—A device for silencing the noise of the exhaust.

Sonoscope—An instrument for determining the location of vibration or "pound" in a motor.

Spark Break—The interruption or breaking of an electrical circuit to produce a spark.

Spark Coil—A coil of either the primary or induction type which intensifies the electrical current and produces a hotter and larger spark.

Spark Plug—A plug fitted into the cylinder and insulated therefrom and provided with electrodes or terminals which produce the spark.

Sparking Points—The two terminal points or electrodes from which the spark is produced.

Spindle—A round rod or bar. The tapered or reduced end of a shaft.

Sprocket—A wheel provided with teeth which fit into the links of a chain for transmitting power or motion.

Sprocket Chain—The chain used on a sprocket wheel.

Spur Gear—A form of cog-wheel or gear-wheel in which the teeth are sharp or pointed.

Street Elbow—A pipe elbow in which one end is male- and the other female-threaded.

Stud—A piece of projecting metal to which a nut may be attached; a lug.

Stud Bolt—A bolt threaded at each end so that it may be screwed into a threaded hole and a nut screwed onto the projecting portion.

Stuffing Box—A box or casing through which a shaft passes and which may be packed to prevent leakage around the shaft.

Suction Stroke—The stroke of the piston which draws the charge of gas into the cylinder or crank case.

Switch—A device by which the electrical current may be turned on or off.

Tachometer—An instrument for measuring the number of revolutions of a wheel or other object.

Tap—A tool for cutting female threads in nuts, holes, etc.

Taper Pin—A round, tapered pin used to hold two parts of machinery together; especially for fastening a shaft to a wheel or gear.

Templet—A pattern or guide for duplicating parts.

Terminal—The end of a wire or electrical connection.

Thermal—Relating to heat.

Thermal Efficiency—The proportion of heat utilized by the engine as indicated by the power developed as compared with the total heat contained in the fuel used.

Thermal Units—The quantity of heat required to raise one pound of pure water from 32 degrees to 33 degrees Fahr.

Thread—A spiral groove cut in a screw, or in a hole, into which a screw is fitted.

Throttle—Any device for regulating the speed of a motor by increasing or decreasing the amount of gas entering the combustion chamber.

Thrust—The forward tendency or push of a shaft when operating under a load.

Thrust Bearing—The bearing designed to overcome the friction of the thrust.

Timer—A device for interrupting and connecting the electrical circuit at certain intervals in order to produce a spark at the correct time.

Timing—So regulating the timer, or the valves of a motor, as to operate at the proper time to develop the best results.

Torque—A twisting or turning force.

Two-cycle—A form of motor in which an explosion or impulse occurs on every upward stroke of the piston or on every complete revolution of the crank shaft.

Union—A device for connecting two pieces of pipe so that they may be connected or disconnected without disturbing the rest of the pipe.

Valve—A device for opening or closing a passage.

Valve Box—The casing in which a valve moves.

alve Cam—A cam which operates a valve.

alve Chamber—The chamber within which the valve is placed.

alve Foot—The lower portion of a valve upon which push-rods or cams operate.

alve Gear—Gears for operating the valves.

alve Port—The opening through, or beneath, a valve which is opened or closed by the action of the valve.

alve Rod—A rod for operating a valve.

alve Seat—The portion of the valve box upon which the valve rests when closed. In a rotary or slide valve the portion around the valve against which it bears.

alve Stem—The spindle or shaft that connects the valve with its foot or handle.

porizer—A device for vaporizing or transforming liquid fuel to a gaseous state by mixing it with air.

brator—The part of an induction coil which automatically opens and closes the circuit of electricity through the coil.

lt—A unit of measurement of electricity denoting the force of current. Analogous to pressure.

ltage—The amount of volts produced by a battery or generator and which will flow from it when a circuit is completed.

ltmeter—An instrument for measuring voltage.

-motor—A form of gas engine in which the cylinders are placed at angles with one another or in "V-shape."

-thread—A screw thread in which the grooves are angular with sharp or "V-shaped" angles.

aste Nut—A flange or plate for fastening pipes to a floor or wall.

ater-jacket—The casing outside of a cylinder and which contains the circulating water.

eb—The thin portion of a wheel connecting the hub with the rim.

hitworth Thread—A particular form of screw-thread differing from the ordinary threads in the shape of the grooves. The standard British thread.

ipe Break—A form of make-and-break spark in which the spark is produced by one electrode rubbing or passing over the other.

ipe Spark—A spark produced by a wipe break.

ire Drawing—The pull or resistance caused by overcoming friction or pressure against moving gas, or in overcoming the resistance to a spring.

oodruff Key—A form of key which is straight on one side but semicircular on the other. Used as a key to hold wheels or gears on a shaft where the end of the key cannot project.

Worm Cam—A cam provided with a "worm" or spiral groove or projection.

Worm Gear—A gear which is grooved in a spiral or "screw" manner instead of being provided with cogs.

Worm and Segment—A form of gearing composed of a worm gear and a sector of a cog-wheel or pinion.

Wrist Pin—The pin which holds the connecting rod to the crosshead.

APPENDIX

HEAT VALUE OF FUELS.

e following table is given on good authority but will be found
y considerably from many other tables.)

Fuel	Br. Th. Units per lb.	Br. Th. Units per cu. ft.
ogen at 32° F	62,030	348
n	14,500	. . .
n monoxide (C.O.)	4,396	539
ylvania heavy crude oil	20,736	. . .
sian crude oil (heavy)	20,138	. . .
sian crude oil (light)	22,027	. . .
leum refuse	19,832	. . .
acite gas	3,484	. . .
ndle-power illuminating-gas	. . . . .	950
ndle-power illuminating-gas	. . . . .	800
ndle-power illuminating-gas	. . . . .	620
York City water gas (60° F. at 30 lbs. ssure,	. . . . .	710.5 Ave.
on coal-gas	. . . . .	668
ne (C_6H_6)	18,448	. . .
ene and its vapor	21,900	690
ene (C_2H_4)	21,430	1,677
h-gas (CH_4)	23,594	1,051
al Gas, Leechburg, Pa	. . . . .	1,051
al Gas, Pittsburg, Pa	. . . . .	892
lene (C_2H_2)	21,492	868
water gas	. . . . .	185
ucer-gas	. . . . .	150

inches	inch	Diam. inches	Diam. inches	Inch
¼	18	.36	.54	.08
⅜	18	.49	.67	.09
½	14	.62	.84	.10
¾	14	.82	1.05	.11
1	11 ½	1.04	1.31	.13
1 ¼	11 ½	1.38	1.66	.14
1 ½	11 ½	1.61	1.9	.14
2	11 ½	2.06	2.37	.15
2 ½	8	2.46	2.87	.20
3	8	3.06	3.5	.21
4	8	4.02	4.5	.23
5	8	5.04	5.56	.25
5	8	6.06	6.625	.28

DIMENSIONS OF DRILLS FOR STANDARD V

Diam of Screw	Threads Per Inch	Diam. of Bottom of Thread	Ne Dr Full
¼	20	.163	

CAPACITY OF CYLINDRICAL TANKS.

Dimensions Inches	Capacity in Gals.	Dimensions Inches	Capacity in Gals.
9×20	5 gallons	18×30	32 gallons
10×20	8 "	18×40	40 "
12×20	10 "	18×42	45 "
12×24	12 "	18×48	50 "
12×30	15 "	20×40	50 "
14×30	20 "	20×48	65 "
14×36	24 "	20×60	80 "
16×30	26 "	22×50	80 "
16×36	32 "	22×60	100 "

TABLE OF CAP-SCREW SIZES.

am.	Threads Per in.	Hexagon Head		Square Head		Philister Head Diam.	Round Head Diam.
		Short Diam.	Long Diam.	Short Diam.	Long Diam.		
1/4	20	7/16	1/2	7/16	5/8	3/8	7/16
5/16	18	1/2	37/64	1/2	45/64	7/16	9/16
3/8	16	9/16	41/64	9/16	51/64	9/16	5/8
7/16	14	5/8	23/32	5/8	29/32	5/8	3/4
1/2	12	3/4	53/64	3/4	1 1/16	3/4	13/16
9/16	12	13/16	15/16	13/16	1 5/32	13/16	13/16
5/8	11	7/8	1	7/8	1 1/4	7/8	1
3/4	10	1	1 5/32	1	1 7/16	1	1 1/4
7/8	9	1 1/8	1 23/64	1 1/8	1 39/64	1 1/8	. . .
1	8	1 1/4	1 7/16	1 1/4	1 13/16	1 1/4	. . .

U. S. STANDARD SCREW THREADS

(Angle of threads 60°. Flat at top and bottom for 1/8 of pitch.)

Diam. Screw	Threads Per In.	Diam at Root of Thread
¼	20	.185
5/16	18	.240
⅜	16	.294
7/16	14	.344
½	13	.400
9/16	12	.454
⅝	11	.507
¾	10	.620
⅞	9	.731
1	8	.837
1 ⅛	7	.940
1 ¼	7	1.065
1 ⅜	6	1.160
1 ½	6	1.284
1 ⅝	5 ½	1.389
1 ¾	5	1.491
1 ⅞	5	1.616
2	4 ½	1.712
2 ¼	4 ½	1.962
2 ½	4	2.176
2 ¾	4	2.426
3	3 ½	2.629

Nut and bolt head sizes are determined by the following rules, which apply to both square and hex. nuts.

Short diam. of rough nut = 1 ½ × diam. of bolt + ⅛ in. Short diam. of finished nut = 1 ½ × diam. of bolt + ⅛ in. Thickness of rough nut = diam. of bolt. Thickness of finished nut = diam. of bolt − ⅛ in. Long diam. of hex. nut = short diam × 1.155. Long diam. of square nut = short diam. × 1.414.

To Find Surface and Volume.

Area of Rectangle = length × breadth. *Area of Triangle* = base × 1/2 height.

Diameter of Circle = radius × 2. *Circumference of circle* = diam. × 3.1416.

Area of Circle = square of diameter × .7854.

Area of Sector of Circle = area of circle × degrees in arc ÷ 60.

Area of Surface of Cylinder = circumference × length, plus area of both ends.

Volume of Cylinder = Area of section in sq. inches × length in inches and divide by 1728 to find cubic ft.

Diam. of Circle with given Area. Divide area by .7854 and extract square root.

Surface of Sphere = square of diam. × 3.1416.

Volume of Sphere = cube of diam. × .5236.

Side of Inscribed Cube = radius of sphere × 1.1547

Volume of Cone or Pyramid either Round, Square, or Triangular = area of base × ⅓ its height.

A Gallon of Water = 231 cubic inches and weighs 8⅓ lbs. (U. S. Standard).

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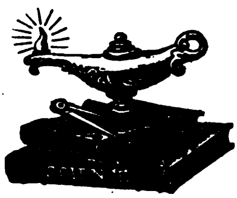

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